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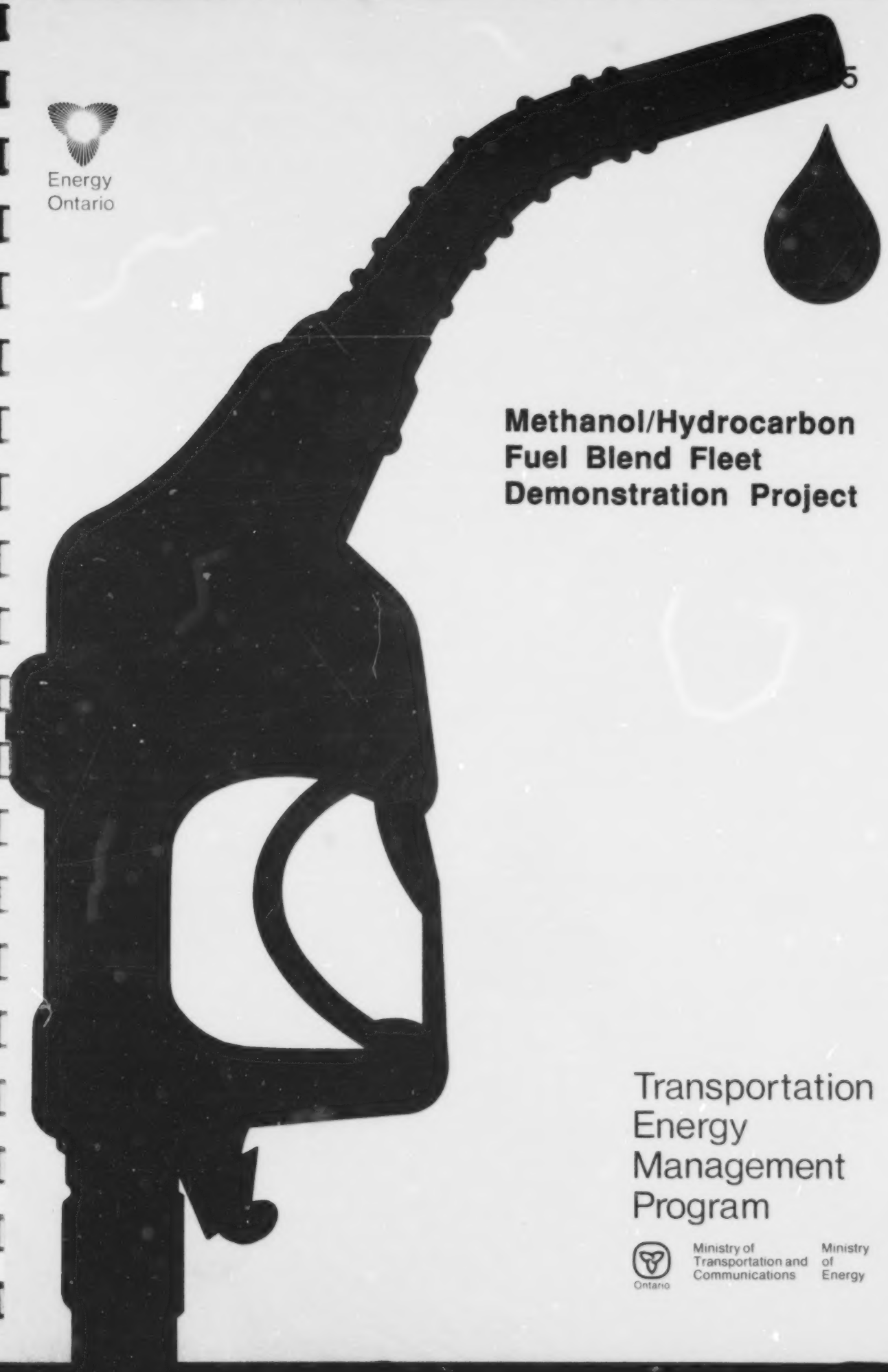

Methanol/Hydrocarbon Fuel Blend Fleet Demonstration Project

Transportation
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Ontario
Ministry of Transportation and Communications
Ministry of Energy

AF-86-05

Methanol/Hydrocarbon Fuel Blend Fleet Demonstration Project

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Abstract:
A joint project involving Alberta Gas Chemicals Ltd. (AGCL), the Ontario Ministry of Transportation and Communications (MTC), and Suncor Inc. began in 1982, consisting of a fleet test of a low-level blend of methanol/co-solvent/hydrocarbon vehicle fuel. The test involved a fleet of 39 MTC vehicles, closely monitored via driveability, exhaust emissions, fuel consumption, air/fuel equivalence ratios, engine oil analysis, driver comments, and maintenance records. It was successfully demonstrated that an oxygenated specification gasoline can be produced and maintained in fleet usage, replacing regular unleaded gasoline.

Key Words: methanol blends, alternative fuels, vehicle testing

Comments:

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PREFACE

This project forms part of the Transportation Energy Management Program supported by the Ontario Ministry of Energy and the Ontario Ministry of Transportation and Communications. This report has been prepared by the Ministry of Transportation and Communications (MTC)as part of its contribution to a joint study with Alberta Gas Chemicals Limited (AGCL) and Suncor, Sunoco Group. It covers Phase 1, from June 1982 to June 1984, using an oxygenated hydrocarbon fuel (70:30 ratio of methanol/isopropanol [IPA] as 10% by volume with unleaded gasoline).

The Ontario Ministry of Transportation and Communications (MTC) supplied the 39 test vehicles, conducted chassis dynamometer and driveability tests, and was responsible for the overall supervision of the project. Alberta Gas Chemicals Ltd. (AGCL) provided the methanol used in the test fuel blend, pre-blending of the methanol/isopropanol components, expertise regarding the alcohol components in the fuel, and was involved in project definition. Suncor Inc. provided fuel blending, supply, and analysis; oil analysis; alcohol blend marketing experience; and contributed to project definition.

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EXECUTIVE SUMMARY

In June of 1982, Alberta Gas Chemicals Ltd. (AGCL), the Ontario Ministry of Transportation and Communications (MTC), and Suncor Inc. began a joint fleet demonstration project to test a mixture of methanol and co-solvent alcohol components which, when blended together with hydrocarbon components, met the specifications of unleaded gasoline. The purpose of the demonstration was to assess the operational and economic aspects relating to using such a blend in a fleet of unmodified gasoline vehicles. Methanol (methyl or wood alcohol) is an alcohol which is now produced from Canada's abundant natural gas resources. It could be used neat as a high-octane fuel or in blends with gasoline hydrocarbons. Methanol is also a high-octane blending component and could be used, in part, to replace lead antiknock compounds. It displaces other high-cost octane components. This project was designed to examine the acceptability of a fully formulated fuel blend, containing 10% total alcohols, used in MTC fleet vehicles operating under Ontario weather conditions.

The fuel blend had a volumetric composition of 90% hydrocarbons, furnished by Suncor, and 7% methanol with 3% co-solvent (isopropanol), supplied by AGCL. It was denoted as S1.0 (Suncor 1.0) and was designed to meet the Canadian Government Specifications Board (CGSB) specifications for unleaded gasoline with an octane rating between 89 and 92 ((R+M)/2). A commercial anti-corrosion additive was added to the S1.0 fuel at the time of blending, along with the appropriate detergent and dispersant. Due to methanol's lower energy content, the seasonal S1.0 fuel blends used throughout the project had an average of 6% less energy than hydrocarbon gasoline. Blend volatility was seasonally adjusted according to the normal practice for commercial hydrocarbon gasoline. Monthly fuel samples were taken from the MTC Downsview dispensing facilities and quarterly from the Suncor terminal storage location.

The fuel blend was tested in a fleet of 39 MTC vehicles, and their performance was evaluated by closely monitoring driveability, engine oil, emissions, fuel consumption, equivalence ratios, driver comments, and maintenance records.

Driveability tests were performed on a continuous basis by test drivers, who evaluated the vehicles on a specially designed 23.6 km route. The results showed that the driveability of the fleet vehicles on gasoline and on the blend was similar, with the blend having the tendency to exacerbate problems that were already evident when using unleaded gasoline. Regular fleet drivers confirmed this conclusion. No vehicle was declared unsuitable for service when running on the blend or when being cross-fuelled with gasoline. Due to the way the vehicles were used, they were cross-fuelled, on average, 50% of the time.

Oil samples were taken regularly from each fleet vehicle. Used lubricant quality and wear metal analyses were conducted by Suncor and Wear-Check of Toronto. They indicated that the use of S1.0 did not lead to unusual lubricant deterioration. The wear metals analyses showed that the vehicles exhibited no increased wear with S1.0.

Chassis dynamometer tests were done by MTC on nine of the fleet vehicles, designated as Fleet A, using both S1.0 and gasoline. Each vehicle was tested for emissions and fuel consumption. Six Fleet A vehicles were tested for equivalence ratios.

In general, exhaust emissions of the vehicles met Canadian standards while using the S1.0 blends. Carbon monoxide (CO) emissions were significantly lower; unburned hydrocarbon (HC) emissions, somewhat lower; and nitrogen oxide (NO_x) emissions, about the same as with hydrocarbon gasoline.

There was no significant difference in the volumetric fuel consumption of S1.0 compared to gasoline. The energy consumption of most vehicles while using S1.0 was equal to or less than that experienced with gasoline.

Equivalence ratio measurements carried out by MTC on the Fleet A vehicles confirmed that the use of the methanol blend shifts the gasoline engine to operate at leaner air/fuel ratios. The results from this work are consistent with the published data from other sources in Canada and the United States.

1/ INTRODUCTION

The trend over the last decade toward alternatives to gasoline and diesel fuels has brought many new fuels under consideration. Alcohols have received particular attention because they may be used in low volume percent blends with gasoline hydrocarbons. These blends are immediately practical because unmodified gasoline engines are able to use them. Furthermore, alcohol blends have the advantage of displacing crude oil, while permitting the use of facilities designed to distribute and dispense gasoline.

The high antiknock quality of alcohols has made them good candidates as octane enhancers. While there are problems to be addressed before using alcohol as a replacement for lead, it is the belief of alcohol proponents that these concerns can be economically resolved.

The most available alcohol in Canada is methanol (methyl or wood alcohol). Methanol is manufactured primarily from natural gas and is being produced jn three world-scale industrial plants in Western Canada. Co-solvents such as isopropanol, ethanol, and until recently, isobutanol are also produced in Canada but in smaller quantities. The relatively low cost of producing methanol from natural gas makes methanol a candidate for use as a gasoline additive for both volume extension and octane improvement.

Several test programs have been conducted on fuel blends of methanol and gasoline in different parts of the world. In Germany, government and industry have been co-operating for a number of years to test the use of neat methanol and various methanol/co-solvent/gasoline blends as transportation fuels. West Germany is using 3% (by volume) methanol/ co-solvent blends commercially in more than half the gasoline sold. Companies, including Volkswagen and Daimler-Benz, are conducting investigations on engine wear effects, cold starting, and emission levels. In the United States, both government and industry have shown considerable interest in methanol blends, and many test programs have been undertaken. One major refiner (ARCO) has been marketing a 3.5% (by weight) oxygen blend since 1982. Government has been a major party in the evaluation of methanol blends in Ontario. Research is currently under way, sponsored

by the provincial Ministry of Energy and directed by the Ministry of Transportation and Communications (MTC). The Ontario Research Foundation is also deeply involved with methanol fuels, as are a number of major corporations.

The Ministry of Transportation and Communications' interest and expectations of alternative fuels research is dictated by Ontario's Energy and Alternative Fuels Policy and Strategy, the main objective of which is to lessen Ontario's dependence on imported oil. The alternative fuel component of that policy requires the encouragement and substitution of alternatives for conventional fuels in Ontario's transportation sector and the securing of private sector participation and investment in alternative fuel production and utilization.

To assess the long-term fleet response of different types of gasoline vehicles to the use of a fully formulated methanol fuel blend on a day-to-day basis in Ontario, a fleet demonstration was necessary. To meet this need, MTC, Alberta Gas Chemicals Ltd. (AGCL), and Suncor, Sunoco Group embarked on a two-year joint fleet demonstration project.

In June of 1982 the three participants began to test a fuel blend containing 10% by volume total alcohols utilizing 7% methanol with 3% isopropanol as the co-solvent. The alcohols were blended with hydrocarbons to produce a fuel which met the specifications for unleaded gasoline. The blend was tested in 39 MTC vehicles, which were unmodified and used for regular daily service throughout the demonstration. Used oil sampling and analysis, driveability evaluations, chassis dynamometer tests for fuel consumption, exhaust emissions, and air/fuel (A/F) ratios were used to monitor the effects of the fuel blend on the vehicles.

To create an environment conducive to the development of methanol as a blending component, technical, financial, and regulatory impediments must be considered. This fleet demonstration was designed to explore many of the critical technical issues: fuel handling, storage, and dispensing; vehicle fuel system and engine compatibility; driveability; emissions; fuel consumption; A/F ratios; and the private sector's perception of of the fuel blend.

1.1/ Technical Considerations

The physical and chemical properties of methanol and gasoline are very different in many respects (Table 1). Methanol is a single compound with well-defined properties, such as density, boiling temperature, and stoichiometric air/fuel ratio. Gasoline, on the other hand, is a mixture of various hydrocarbons and is different from batch to batch, depending on season, processing, and starting crude type.

Table 1/ Properties of Methanol and Gasoline

	Methanol	Gasoline
Chemical Formula	CH_3OH	C_4-C_{12} compounds
Molecular Weight	32.04	100-105 (Avg.)
Composition, wt. %		
Carbon	37.5	85-88
Hydrogen	12.6	12-15
Oxygen	49.9	0
Density at 15°C, kg/L	0.794	0.695-0.779
Boiling Temperature, °C	65	27-225
Flash Point, °C	11	-43
Autoignition Temperature, °C	464	227
Flammability Limits, vol. %		
Lower	6.7	1.4
Higher	36	7.6
Heating Value, Lower		
MJ/kg	19.93	44
MJ/L	15.76	32
Latent Heat of Vaporization		
kJ/kg	1177	approx. 350
Vapour Pressure, kPa at 38°C	31.9	48-103
Stoichiometric A/F Ratio	6.4	14.2-14.8
Water Solubility	Infinite	Insoluble
Octane Ratings		
Research	110	90-100
Motor	92	80-90

The differences between the chemical structures of methanol and the hydrocarbons contained in gasoline result in a non-ideal mixture when they are blended together. In the presence of certain amounts of water, polar methanol will partition between water and the non-polar hydrocarbons, resulting in a phase separation. Phase separation can also occur at very low ambient temperatures in the absence of water. To maintain the integrity of methanol blends, a co-solvent such as isopropanol is used to make the blend less susceptible to phase separation.

Since methanol contains oxygen, whereas gasoline does not, methanol substitution leads to leaner A/F mixtures in unmodified gasoline vehicles. Depending on the initial A/F ratio calibration and individual vehicle sensitivity, leaner operation may cause significant changes in engine performance and exhaust emissions. In general, cold-engine performance could deteriorate with increasing oxygen content, particularly at low ambient temperatures, whereas carbon monoxide (CO) and unburnt hydrocarbon (HC) emissions could decrease due to a more complete combustion of the fuel. One objective of this project was to maximize the methanol content of the fuel blend used without causing major driveability, emissions, or phase separation problems. The alcohol content of the fuel blend was, therefore, carefully chosen to test the operating limits of unmodified gasoline engines, using an oxygenated fuel. Based on previous tests conducted on methanol/co-solvent/gasoline fuel blends, an oxygen level of approximately 4% by mass was chosen for this test program.

On a volumetric basis, methanol has about one-half the energy content of gasoline, namely, 15.76 versus 32 MJ/L. This may cause some power loss and/or an increase in fuel consumption with some vehicles. The latent heat of vaporization of methanol is higher than that of gasoline (1177 versus 350 kJ/kg), requiring more heat energy for vaporization to occur. For the fuel blend used in this program, a fuel with boiling and vaporization characteristics within the range of specification gasoline was produced.

Materials compatibility and long-range durability are also areas of interest with alcohol blends. The literature indicates that problems in this area are a function of alcohol dosage. Emissions, fuel consumption, driveability (cold-start/drive and warm-drive engine performance),

wear and durability, and storage tank phase separation were all followed during the course of this fleet trial.

2/ THE TEST FUEL

There are two limiting factors influencing the amount of methanol and co-solvent used in a fuel blend with gasoline hydrocarbons: the amount of oxygen contained in the fuel and the methanol/co-solvent ratio. Studies in the USA have indicated that 3.5% oxygen (by mass) in the fuel does give some driveability demerits. Using the smallest possible amount of co-solvent reduces the cost of the fuel blend (co-solvents are more expensive than pure methanol). One objective is to develop a methanol/co-solvent ratio in the 2:1 to 3:1 range.

In pursuing the optimum fuel blend composition under these conditions, a blend with 10% total alcohols on a volumetric basis was developed. The fuel was denoted as S1.0 (Suncor 1.0) and was composed of 90% hydrocarbons, 7% methanol, and 3% isopropanol.

Of the various co-solvents available for use in the S1.0 fuel, isopropanol was chosen, primarily, to test the effectiveness of what was considered to be a relatively weak co-solvent (compared to others such as isobutanol [IBA] and tertiary butyl alcohol [TBA]). Furthermore, isopropanol will be obtainable on a long-term basis in this country.

The methanol used in the S1.0 fuel was supplied by AGCL, which has three world-scale production plants in Medicine Hat, Alberta. The isopropanol was obtained and blended with the methanol by an independent company, Van Waters and Rogers, located in Weston, Ontario, under the direction of AGCL. The base fuel, consisting of gasoline hydrocarbon components produced at Suncor's Sarnia refinery, was then blended with the alcohols by Suncor at Gibson Fuels (a Suncor subsidiary) in Brantford. A 22 730 L (5000 imp. gal) underground storage tank and standard gasoline fuel pump located at the MTC Downsview complex were used to dispense the S1.0 fuel to the fleet vehicles. It has been used exclusively for this purpose during the trial.

The S1.0 fuel was designed to meet the Canadian Government Specifications Board (CGSB) specifications concerning unleaded gasoline. To produce a fuel blend which met these gasoline specifications for volatility and boiling range, a special blend of hydrocarbons had to be produced by

Suncor, because a blend of methanol and commercial gasoline would increase the vapour pressure of the blend beyond specification limits.

A multi-functional additive package was added to the S1.0 fuel for cleanliness and corrosion protection. The antiknock quality of the S1.0 fuel blend met the CGSB specifications for unleaded gasoline. The fuels used were all between an octane number of 89 and 91 ([R+M]/2).

Elemental analyses were carried out by independent laboratories on the two summer blends -- S1.0 (82) and S1.0 (83) -- the two winter blends -- S1.0W (82/83) and S1.0W (83/84) -- as well as a baseline unleaded gasoline sample (Table 2).

Table 2/ Analyses of Gasoline and Methanol Blends

		Percentage Composition (wt. %)			Heats of Combustion (MJ/kg)	
Fuel	Density	Carbon	Hydrogen	Oxygen	Gross	Net
Gasoline	0.7301	86.29	13.71	--	48.23	45.19
S1.0(82)	0.7350	.....not available.....			45.09	42.72
S1.0W(82/83)	0.7343	82.58	14.12	3.30	45.89	42.76
S1.0(83)	0.7378	82.42	13.70	3.88	44.24	41.21
S1.0W(83/84)	0.7385	81.93	13.69	4.38	44.47	41.48

NOTES:

- All analyses were done by Energy, Mines and Resources (EM&R) except for S1.0(82), which was done by Guelph Chemical Laboratories Ltd.
- Gross Heat of Combustion (liquid phase water product of combustion) (also called Higher Heating Value--HHV)
- Net Heat of Combustion (gaseous phase water product of combustion) (also called Lower Heating Value--LHV)

2.1/ Fuel Quality and Storage Equipment Monitoring

To monitor the continuing quality of the fuel, monthly fuel samples were taken from the Downsview dispensing facilities and analysed by Suncor. They included fuel storage tank bottom samples as well as pump nozzle samples. The fuel was tested for density, Reid vapour pressure (RVP), distillation, ASTM gums, alcohol content, and octane level, as well as other factors. The product remained on specification throughout the test period (Appendix A).

Phase separation tests were also conducted on a monthly basis. An electronic water-sensing device and a chemical water indicator were both used to check for any aqueous layer at the bottom of the S1.0 fuel storage tank. All tests were negative, signifying that there was no appreciable water content or phase separation at the bottom of the tank.

To determine whether any material wear of the S1.0 fuel dispensing pump components was occurring, monthly calibration tests were done. A 20 L calibration tank was used for this purpose, and in all cases the percentage difference between the pump reading and the calibration tank was less than 1%, within manufacturer's specifications (Figure 1).

The initial seal ring on the in-ground storage tank failed due to swelling within weeks of the beginning of the program. A stock replacement was obtained and has been in place ever since, showing no signs of swelling or deterioration. Tests performed in an independent laboratory were not able to duplicate the failure of the seal ring, even when using replacement seals from the original equipment manufacturer. This may indicate the need to check for seal deterioration at regular intervals after introducing alcohol blends to existing gasoline storage facilities.

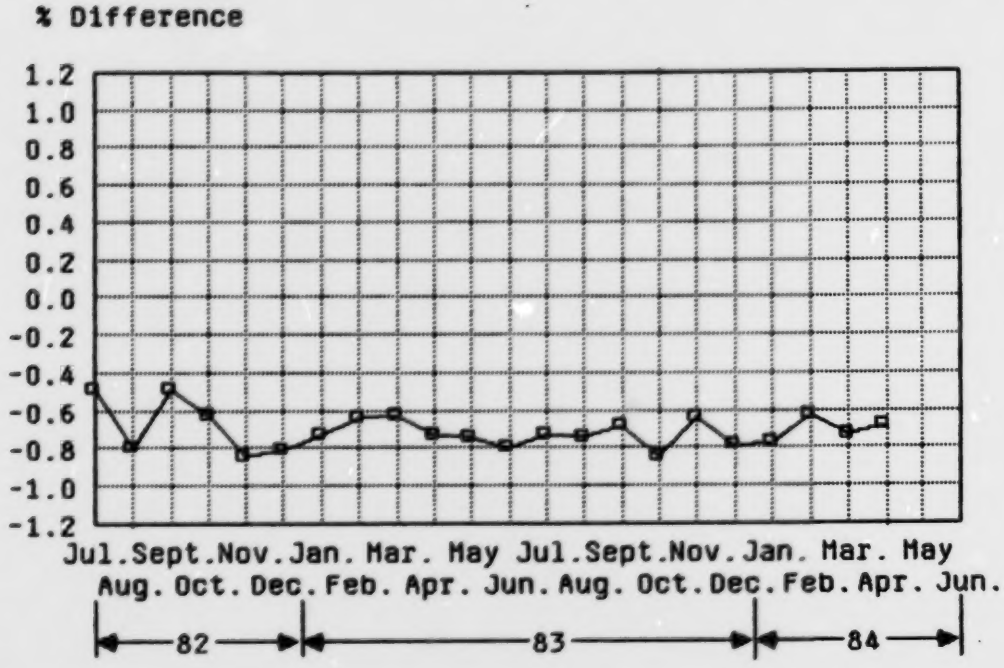

Figure 1/ The Percentage Difference Between the S1.0 Pump and the Calibration Tank

3/ THE FLEET DEMONSTRATION PROGRAM

3.1/ Fleet Description

There were 39 test vehicles participating in this demonstration program. The vehicles were divided into two fleets, A and B. The A fleet was tested on the chassis dynamometer as well as being used in regular fleet service. Fleet B was more representative of a typical fleet operation, where strict control over the type of fuel used was not possible. This resulted in a considerable degree of cross-fuelling with unleaded gasoline. Fleet A had a total of nine vehicles which were to be filled with S1.0 almost exclusively. For every batch of test fuel, the Fleet A vehicles were dynamometer tested for fuel consumption, exhaust emissions, and equivalence ratios. Fleet B had a total of 30 vehicles, to be filled with test fuel whenever possible. Though the fleet vehicles were based at the Downsview complex, where the S1.0 fuel dispensing facilities were located, some were occasionally sent to other locations in the Toronto area and could not fill up with S1.0 consistently. Fleet A averaged about 75% operation on S1.0, whereas fleet B averaged approximately 32%. Cross-fuelling with gasoline took place at service stations and other MTC locations equipped with gasoline dispensing equipment. Complete vehicle descriptions of both fleets are listed in Tables 3 and 4.

Table 3/ Vehicle Description of Fleet A

Vehicle	MTC Veh. #	Cyl.	Displacement L (cu.in.)	Carburetion (bbl)	Odometer at Start of Test
A) 77 Ford Maverick	413	6	4.1 (250)	Motorcraft (1)	48328
B) 78 Chev Impala	209	8	5.0 (302)	Rochester (2)	54450
C) 78 Dodge 3/4 T	1096	8	5.2 (318)	Carter (2)	78124
D) 78 AMC Concord	221	6	3.8 (232)	Carter (1)	64466
E) 80 Ford Fairmont	235	6	3.3 (200)	Motorcraft (1)	45611
F) 80 Ford Fairmont	271	6	3.3 (200)	Motorcraft (1)	38250
G) 81 Fairmont Wgn.	452	6	3.3 (200)	Motorcraft (1)	11954
H) 81 Dodge 1/2 T	1771	8	5.2 (318)	Carter (2)	22670
I) 82 Chrys. Reliant	101	4	2.6 (160)	Mikuni (2)	11445

NOTES:

- The Fleet A vehicles are identified by the letters A to I.
- The 1977 Maverick odometer is in miles. All other vehicles are calibrated in kilometres.

Table 4/ Vehicle Description of Fleet B

Vehicle(s)	MTC Veh. #	Cyl.	Displacement L (cu.in.)	Carburetion (bbl)	
79 Concord Wgn.	1224,1232 1600,1601	6	3.8 (232)	Carter	(1)
80 Dodge Van 1/2 T	1256,1262 1263,1264	8	5.2 (318)	Carter	(2)
81 Dodge Van 1/2 T	1789,1790 1791	8	5.2 (318)	Carter	(2)
82 Dodge Van 1/2 T	141,143,145 153,190	8	5.2 (318)	Carter	(2)
80 Fairmont Wgn.	1172,1173	6	3.3 (200)	Motorcraft	(1)
81 Fairmont Wgn.	455	6	3.3 (200)	Motorcraft	(1)
81 Fairmont Sedan	574,575	6	3.3 (200)	Motorcraft	(1)
79 Chev Van 1/2 T	1606,1630	8	5.7 (350)	Rochester	(4)
80 Chev Van 3/4 T	1154,1155	8	5.7 (350)	Rochester	(4)
81 Chev Suburban	798	8	5.7 (350)	Rochester	(4)
81 Chev Van 3/4 T	844	8	5.7 (350)	Rochester	(4)
81 Concord Sedan	580,581	6	4.2 (256)	Carter	(1)
80 Dodge Pickup	1129	8	5.2 (318)	Carter	(2)

4/ PROGRAM DETAILS AND RESULTS

In addition to the chassis dynamometer work, volumetric fuel consumption of all vehicles was checked every three months. Durability and wear were monitored by analysing periodic oil samples and maintenance logs. Driveability was evaluated by comparing vehicle performance on a pre-defined course with both the test fuels and unleaded gasoline. Driver comments were also requested regularly using a standard survey form.

4.1/ Fuel Usage

Records of volumetric fuel consumption were kept in daily vehicle operation booklets, which were checked quarterly to identify the amount of S1.0 and all hydrocarbon gasoline used. A summary of the fuel consumption data for each fleet vehicle is listed in Appendix B.

Although there were seasonal variations in the amount of fuel usage, 74.4% of the overall fuel consumed in Fleet A vehicles was S1.0 fuel (Figure 2).

Overall, 31.7% of the fuel consumed during the test period in Fleet B vehicles was S1.0 fuel (Figure 3).

The total amount of S1.0 fuel used by both fleets was about 4200 L per month.

4.2/ Dynamometer Testing

The Fleet A vehicles were tested periodically on the chassis dynamometer for fuel consumption, equivalence ratios, and emissions, using the US Environmental Protection Agency (EPA)/Transport Canada test procedure. A Clayton ECE 50 chassis dynamometer was used. A portion of the diluted exhaust emissions was continuously collected into separate bags for each test cycle, using a Horiba Model 20 constant volume sampling (CVS) system. Hydrocarbon emissions were measured with a Horiba OPE-408 flame ionization detector. Carbon dioxide and carbon monoxide concentrations were measured by a Horiba Model 105 non-dispersive infrared analyser. Nitrogen oxides were measured by a Thermo Electron Corp. chemiluminescent

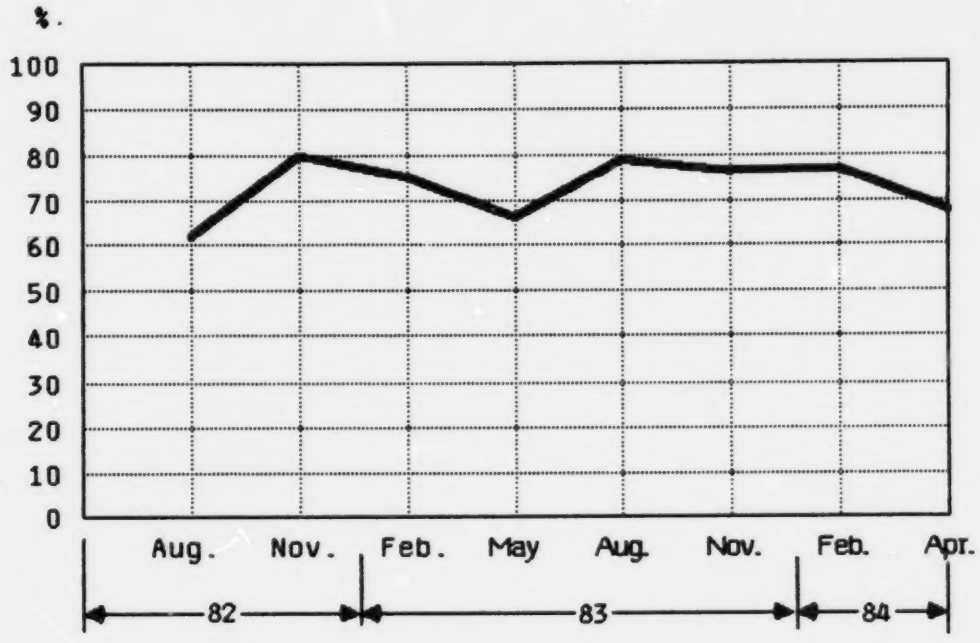

Figure 2/ Percentage of S1.0 Fuel Consumption in Fleet A (Quarterly Basis)

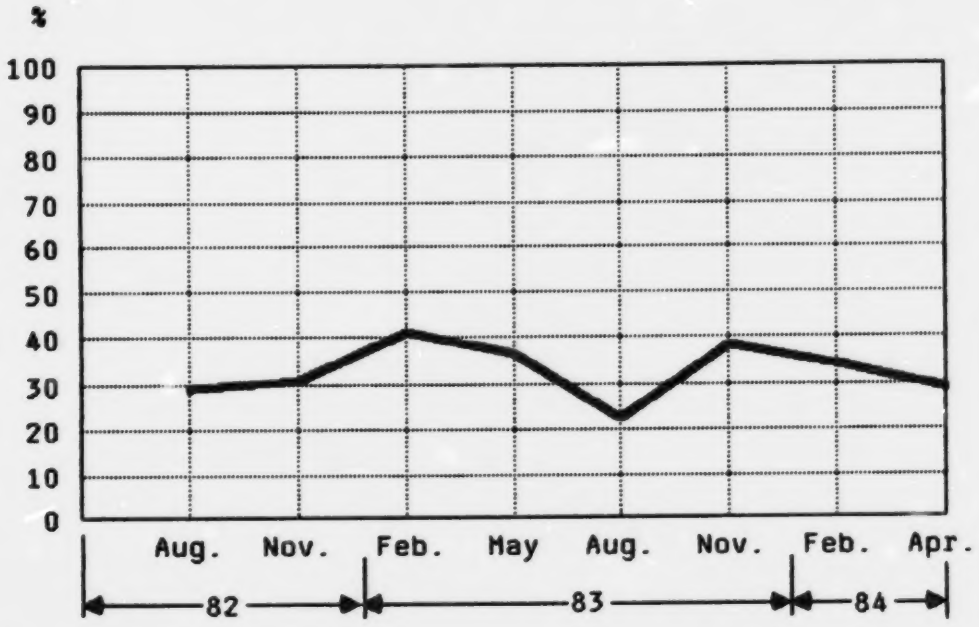

Figure 3/ Percentage of S1.0 Fuel Consumption
in Fleet B (Quarterly Basis)

analyser.

The energy consumption values were calculated from the volumetric fuel consumption data by using the lower heating value of the fuel, obtained by measuring the net heat of combustion in a bomb calorimeter. A sample calculation is given in Appendix C.

Four S1.0 fuel blends and one baseline gasoline sample were tested with each Fleet A vehicle. Detailed results of the energy consumption and exhaust emission data are tabulated in Appendix D.

4.3/ Fuel and Energy Consumption

The S1.0 blends were approximately 5% lower in energy content than gasoline (on a volumetric basis); however, volumetric consumption of the blends versus regular unleaded gasoline was about the same. The combined weighted averages of the urban and highway fuel consumption with each fuel are shown in Figure 4, and the same values in energy units are shown in Figure 5.

Figure 4 indicates that while the volumetric fuel consumption of the vehicles is sometimes higher for the S1.0 blends, the values are often lower. Only Vehicles H and D show a consistent increase in fuel consumption for the alcohol blends. Vehicles E, F, and I show little difference in volumetric fuel consumption values between the S1.0 and the baseline gasoline.

Figure 5 indicates that the energy consumption of most vehicles while using S1.0 is comparable to that with gasoline. Vehicles A and I had average energy efficiency improvements of 6 and 11%, respectively, for the alcohol blends. Vehicles E and F, which are identical, show values in close agreement for all the fuels tested. For the three vehicles, B, C, and H, which experienced some inconsistencies in the values for methanol blends, greater random errors in the testing measurements were also observed, indicating variations in the behaviour of the vehicles over a prolonged period of time. Although Vehicles C and H have the same engine configuration, the energy consumption values of Vehicle C are consistently higher than those of Vehicle H. This difference is due to

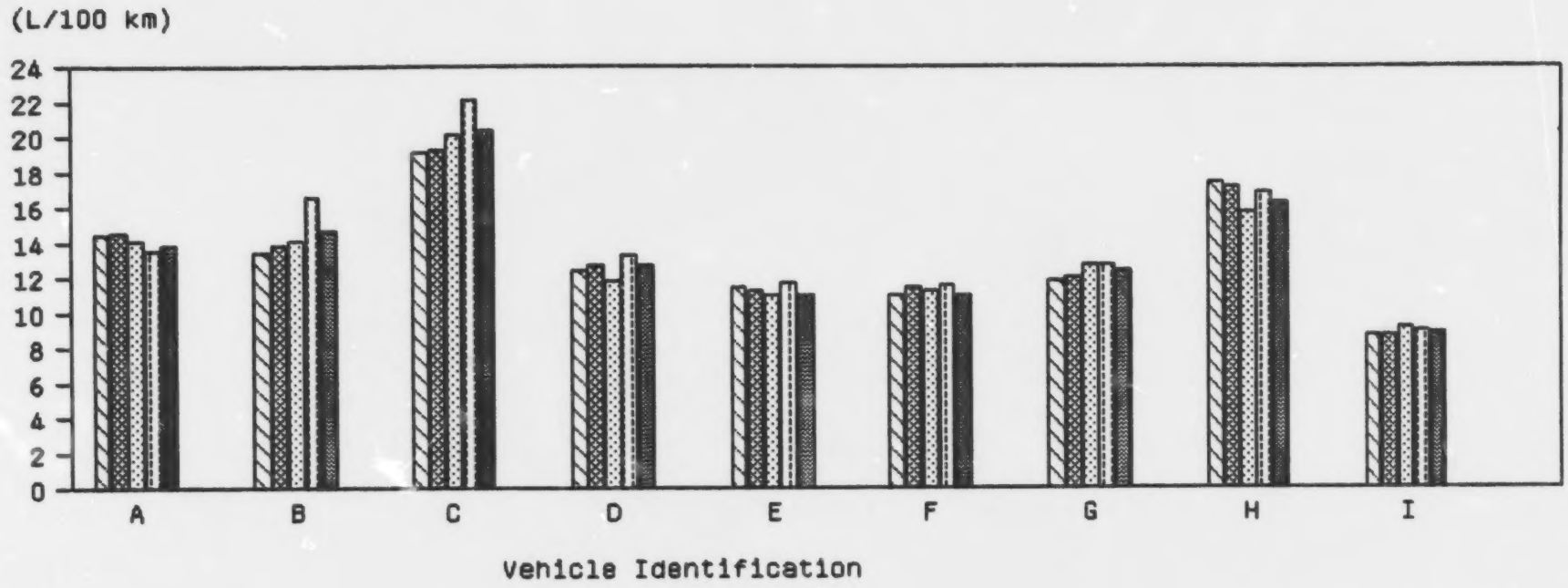

Figure 4/ Volumetric Fuel Consumption (Combined Cycle)

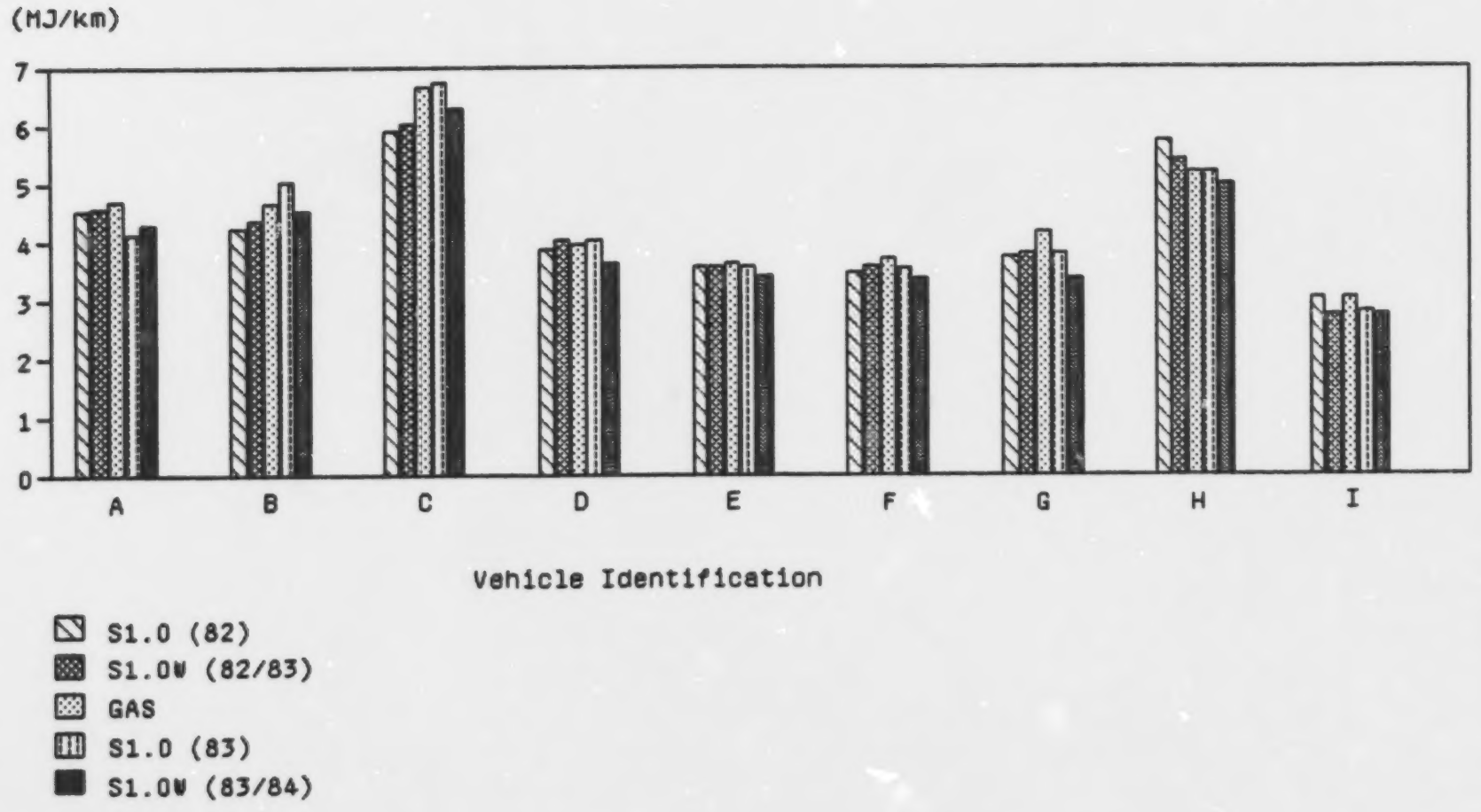

Figure 5/ Energy Fuel Consumption (Combined Cycle)

the inertia weight of Vehicle C, which is 227 kg (500 lb) heavier than Vehicle H.

4.4/ Exhaust Emissions

The use of methanol blends generally shifts the gasoline engine to operate at leaner air/fuel ratios. The values of exhaust emissions obtained with baseline gasoline and the four fuel blends are shown in Figures 6, 7, and 8. The leaning effect of the oxygenated fuels usually resulted in a reduction of carbon monoxide (CO) emissions. Vehicle I displayed a drop in CO emissions from 15 g/mi for gasoline to approximately 6.5 g/mi on the blends. The light-duty vehicles use emissions control equipment such as exhaust gas recirculation (EGR). The CO levels are below the current Canadian standard (25 g/mi) except for vehicle G, which was below the standard only when operating on the methanol blends.

The hydrocarbon emissions (HC) are generally less with the methanol blends than with gasoline. The values are at or below the Canadian standard of 2.0 g/mi, except for Vehicle A, which was above standard with the S1.0 (83) and S1.0(83/84) blends. With Vehicle D, the values increase for the methanol blends compared with gasoline.

The nitrogen oxide (NO_x) emissions resulting from operation on the blends are comparable to those obtained on gasoline, with no readily identifiable trend. The current Canadian standard is 3.1 g/mi (maximum).

4.5/ Equivalence Ratio

Equivalence ratio measurements were conducted on six Fleet A vehicles, using summer and winter S1.0 fuel blends and baseline gasoline. A Beckman 957 analyser was used to measure the equivalence ratio shift of the methanol fuel blends. The measurements were made at the following constant speeds -- 96.6, 88.5, 80.5, 64.4, 48.3, and 32.2 km/h (60, 55, 50, 40, 30, and 20 mph, respectively) -- and at idle.

The addition of alcohol to the hydrocarbons was expected to lean the A/F ratio of the gasoline calibrated engine. Figure 9 shows that the

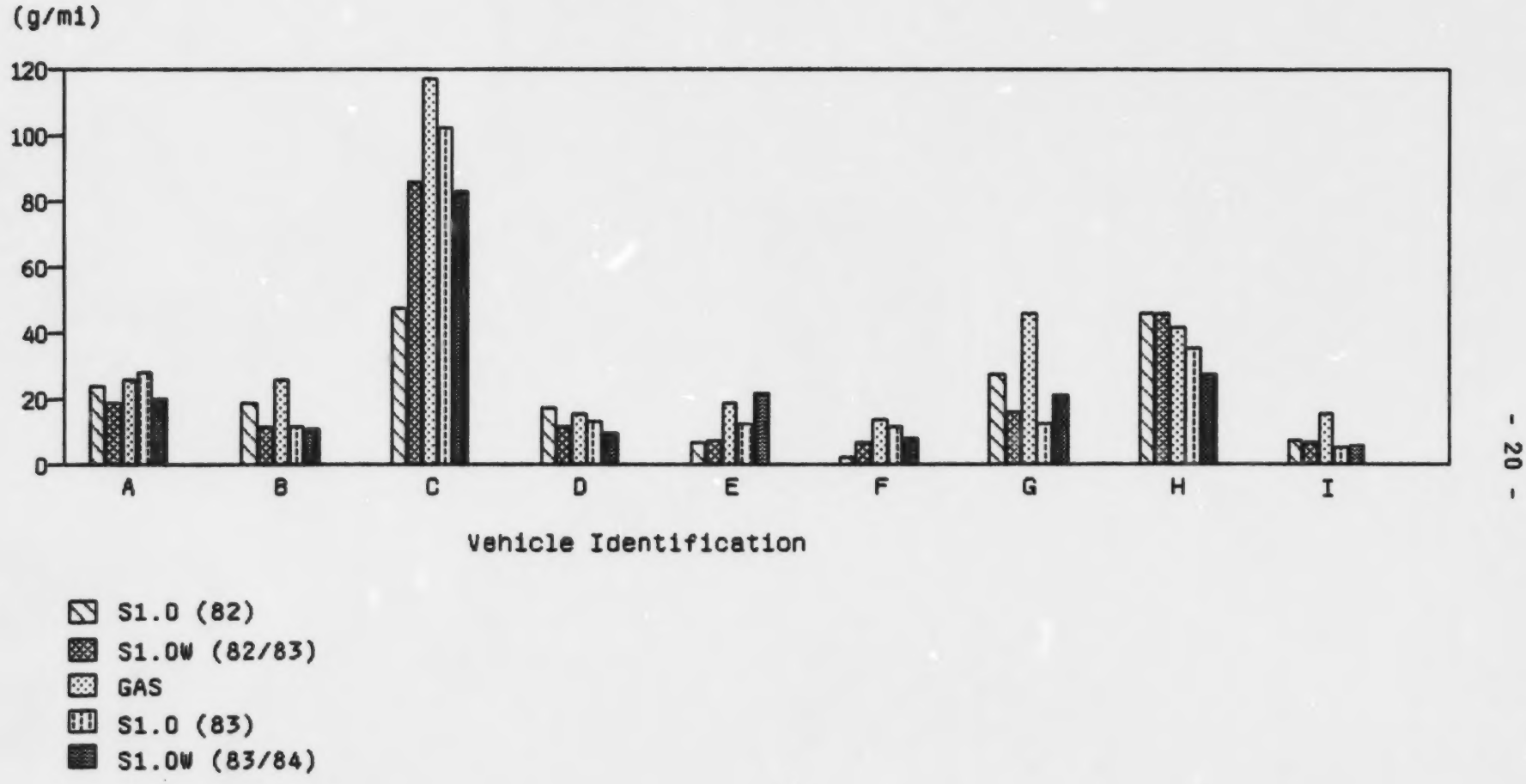

Figure 6/ Carbon Monoxide Emissions

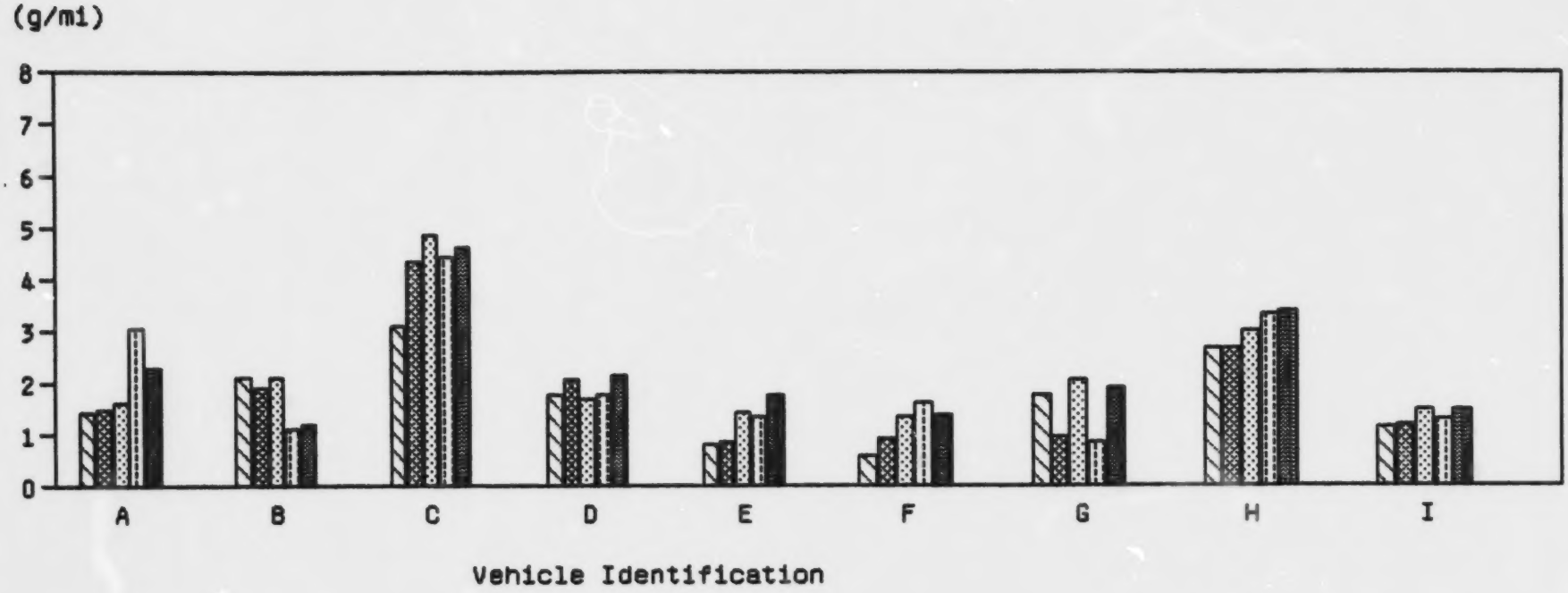

Figure 7/ Hydrocarbon Emissions

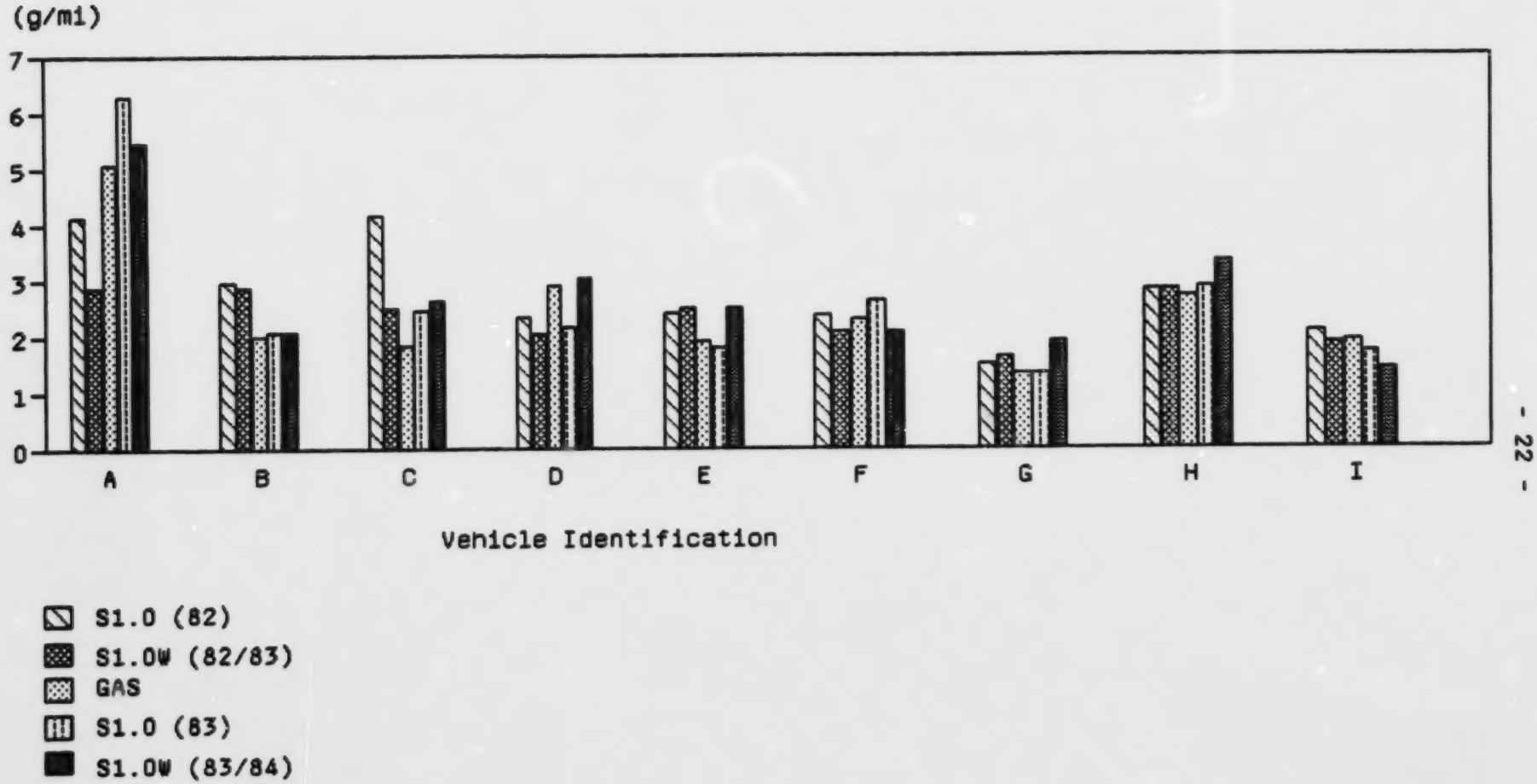

Figure 8/ Nitrogen Oxide Emissions

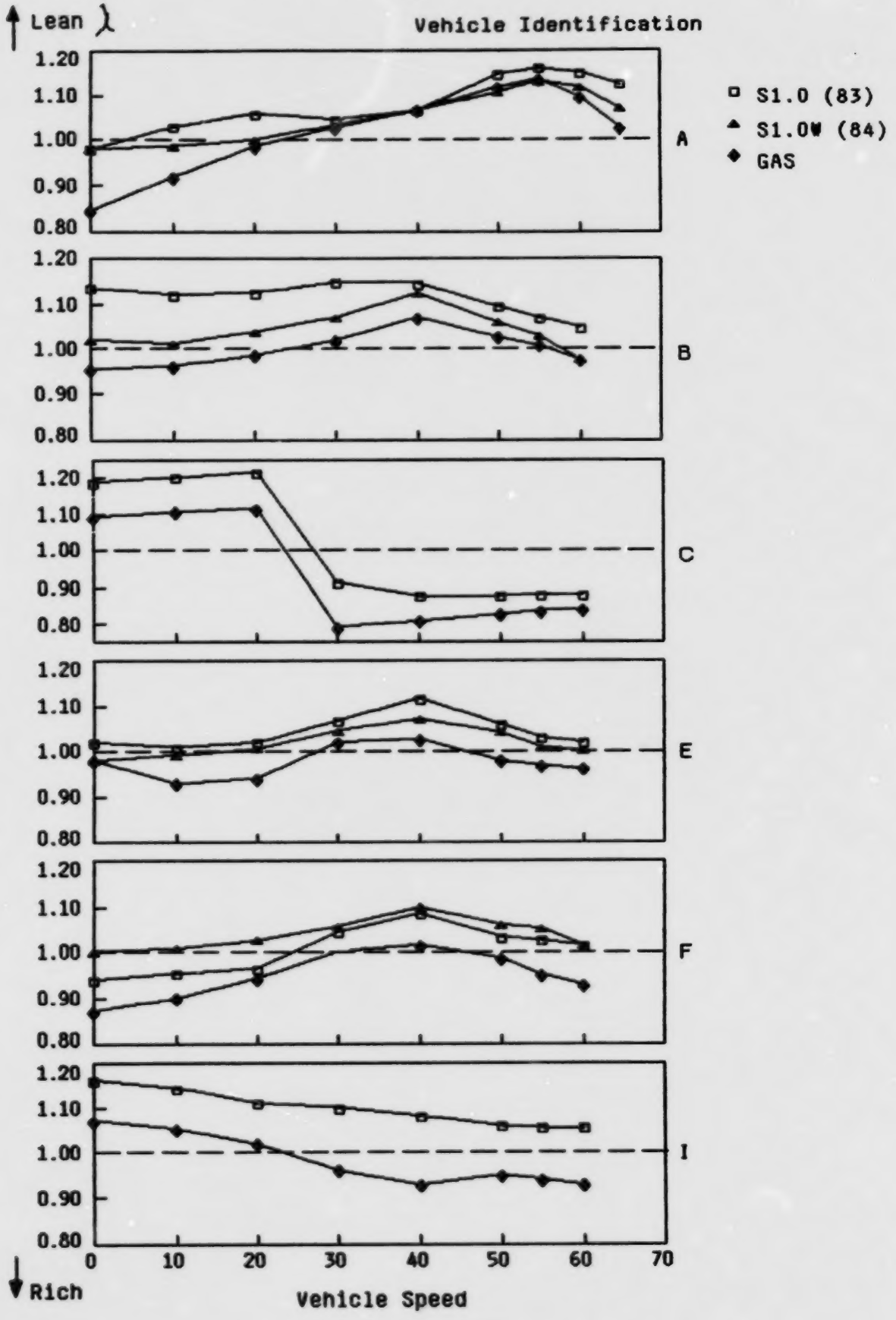

Figure 9/ Equivalence Ratio vs. Vehicle Speed

separation between the equivalence ratios for gasoline and the S1.0 fuels is generally greater than the expected difference of about 5.3%, based on the difference in energy content of the two fuels. Vehicles B, E, and F best exemplify this difference. For many of the vehicles, the equivalence ratio curves show a peak at about 64 km/h (40 mph), which reflects the most optimum engine operation point of most vehicles. At speeds greater than 80 km/h (50 mph), the equivalence ratios turn richer for increased power. Vehicle C shows an abrupt swing in ratios for all fuels between 32 and 48 km/h (20 and 30 mph, respectively), indicating a transition in the operation of the carburetor. For most vehicles there are differences in observed equivalence ratios between the summer and winter grade S1.0 blends, though their heating values are approximately the same, namely, 41 to 42 MJ/kg.

4.6/ Engine Wear Analysis

To determine the effect of the methanol blends on lubricants and engine wear, a comprehensive oil sampling and analysis program was employed. The oil analyses examined three areas: oil and additive condition, oil contamination, and engine wear. Oil degradation is determined by such factors as changing viscosity, decreasing total base number (TBN), and pentane and toluene insolubles (gum formation). Oil contaminants that reduce the oil's lubricating ability include fuel, coolant, and dirt. The level of wear metals in the oil indicates whether or not engine components are undergoing excessive wear. Additive loss can also be determined by metals analysis. Initially, the oil and filter change interval for all vehicles was 6000 km, but it was increased to 10 000 km in the spring of 1983 to allow increased exposure on the oil samples. The sequence of oil sampling is shown in Appendix E.

A total of 253 samples were taken over the duration of the program, and most vehicles were sampled at least six times. Most test vehicles used a 15W40 multi-grade engine oil, a typical heavy-duty oil used in fleets.

4.7/ Base Oil Analysis Results

Base oil quality was examined by Suncor at their Toronto laboratory. Standard ASTM tests were used to determine the flash point, viscosity,

TBN, pour point, pentane and toluene insolubles, and glycol content (coolant contamination). The results of some of these tests are shown in Tables 1 and 2 of Appendix E. The data show that the use of the methanol blends had no adverse effect on the lubricating quality of the engine oil. The results were normal and consistent with those found when using all-hydrocarbon gasoline. An analysis of unused 10W40 engine oil is provided in Table 5 of Appendix E for comparison purposes.

The average TBN value of the oil samples was 5.8, well within acceptable limits. It was observed that in instances where the TBN level dropped significantly, the oil sampling distance was large.

The viscosity level of the engine oil is one of the best indicators of oil condition. Normally, a 25% change in viscosity is a warning that the oil is reaching the end of its useful life. Oil viscosity increases due to the evaporation of lighter base oil fractions and decreases because of fuel or coolant contamination.

The viscosity index (VI) is the measure of viscosity change with temperature and is part of the oil analyses. The unused oil viscosity index was measured as 141, and all oil samples, with the exception of four, were within 25% of this number. There were three Fleet B vehicles that had oil samples exhibiting abnormal viscosity index levels: 79-1630, 81-1789, and 82-141. These vehicles consumed S1.0 at averages of 0, 20.7, and 18.9%, respectively, over the duration of the test. Because of this low blend usage, the viscosity changes cannot be attributed to the use of the S1.0 fuel.

The viscosity of the unused oil at 40°C and 100°C was 108.2 and 14.8 cSt, respectively. The used oil samples were generally within 25% of these values. The lack of significant decreases in viscosity levels is a strong indication that there was no significant S1.0 fuel dilution of the oil.

Pentane and toluene insolubles measurements were made to evaluate the dissolved and dispersed solids in the engine oil. These substances are generally trapped in the oil filter, and when the levels of pentane and toluene insolubles reach 0.5 to 1.0% by mass, an oil filter change is

usually needed.

The glycol measurements were done to check for coolant contamination of the oil. All results showed negligible glycol content in the oil.

Elemental analyses of the oil samples were conducted by an independent laboratory, Wear-Check Inc. of Toronto, using spectrography. Elements monitored were aluminum, boron, chromium, copper, lead, magnesium, nickel, silicon, silver, tin, sodium, and zinc. In addition, the viscosity, percentage of sludge, and dielectric measurement were determined for each sample.

The results of the elemental analyses, shown in Tables 3 and 4 of Appendix E, indicate that relative to the average engine, nine vehicles were showing accelerated engine wear: three from Fleet A and six from Fleet B. The type of wear (slight, moderate, or severe) and the wear metals that were most prominent are identified for each of these vehicles in Tables 5 and 6. The percentage usage of S1.0 with these vehicles ranged from 10.7% with vehicle 81-1790 to 93.4% with vehicle 78-1096.

Among the nine vehicles showing high levels of wear metal concentration, two did not have control oil samples because they were unavailable for oil sampling before the program began. One of the vehicles, 80-1155, had an average S1.0 fuel usage of only 11.5%; thus, it is unlikely that the high level of wear with this vehicle can be attributed to the use of S1.0.

The other vehicle missing a control oil sample, 80-1256, had a 63.7% S1.0 fuel usage value and experienced high iron concentrations in the first two oil samples, which were taken at intervals under 2600 km. However, the following three oil samples, two of which were above 6700 km, returned to normal levels, indicating that the S1.0 fuel was not the cause of the earlier initial increased engine wear.

The remaining vehicles showing high wear levels had control oil samples taken while the vehicles were using gasoline. Of these, only two vehicles experienced a higher level of engine wear after the test fuel was introduced, namely, vehicles 78-1096 and 78-209 in Fleet A. Vehicle

Table 5/ Fleet A Units Showing Wear

Unit Identification	Wear-Metals Analysis Control	Test Fuel	Comments
77-413-000-60 Ford	M/S - wear	M/S - wear	High iron on control. High copper on all test fuel samples
78-209-000-11 G.M.	Normal	M - wear	High copper on almost all test fuel samples. Slightly high silicon.
78-1096-007-20 Dodge	SL - wear	M - wear	All elements high. Moderate silicon levels

Legend: SL = Slight
M = Moderate
S = Severe

Table 6/ Fleet B Units Showing Wear

Unit Identification	Wear-Metals Analysis		Comments
	Control	Test Fuel	
80-1154-007-11 G.M.	SL/M - wear	SL/M - wear	Low odometer reading on control sample. All wear metals slightly high. Iron and chromium moderate. Oil control lost.
80-1155-007-11 G.M.	-	MS/S - wear	No control sample. High iron and copper. Low odometer reading on vehicle.
80-1256-002-20 Dodge	-	S - wear	No control sample. Iron wear high initially. Last two samples normal.
80-1264-002-20 Dodge	S - wear	S - wear	High iron and chromium mainly. Five samples abnormal. Last normal.
81-798-002-11 Dodge	S - wear	S - wear	High iron, chromium, and tin.
81-1790-002-20 Dodge	SL - wear	SL - wear	All elements slightly high. Borderline case.

Legend: SL = Slight
M = Moderate
S = Severe

78-1096 consumed an average of 93.4% S1.0 and had a normal control oil sample followed by two abnormal and three normal oil samples while using the test fuel. The two abnormal oil samples had high concentrations of most elements, particularly iron. Since there were also three oil samples that exhibited normal wear while the S1.0 fuel was used, the evidence for an increase in wear due to the use of S1.0 was not strong.

Vehicle 78-209 consumed an average of 71.3% S1.0 and had a normal control oil sample followed by seven abnormal oil samples. The copper concentrations were particularly high in the oil samples corresponding to test fuel usage. This indicates wear of such engine components as bearings and bushings. Methanol allows greater metal-to-metal contact than gasoline, and the fuel would, therefore, most significantly affect the concentration of iron in the oil, coming from components such as piston rings, which the fuel does come in contact with. There was also moderate levels of silicon found in the oil samples of this vehicle. This would be due to sand, dust, and dirt contaminating the oil and could account for the abnormal wear levels.

5/ DRIVEABILITY

The driveability of the fleet vehicles was assessed by road testing on a test route, where prescribed throttle manoeuvres were performed. Factors under consideration during the evaluations included cold and warm startability, as well as such driving faults as backfires, surges, hesitations, and stalls. The performance of the vehicle was determined by the test driver without the aid of any equipment.

To augment these tests, MTC personnel who drove the fleet vehicles completed vehicle complaint reports to record any operational problems with the vehicles while using either gasoline or the S1.0 blends. In addition, a user survey was conducted midway through the test program in which drivers assigned to a fleet vehicle on a regular basis could make a personal evaluation of the performance of the S1.0 fuel relative to gasoline.

Driveability was assessed by two separate groups:

1/ Fleet A vehicles were used in daily service but selectively evaluated by drivers who had received some training on driveability testing.

- They were not Coordinating Research Council (CRC) trained observers.
- They changed every four months.
- The test course was always the same.
- Climatic conditions were variable.

In this controlled comparison testing, very slight deteriorations in driveability were detected in the blend fuels, as compared to baseline gasoline. However, no effects inhibited the vehicles from performing as required.

2/ Fleet B vehicles were not regularly evaluated by the trained drivers. The normal users did not complain about the vehicle performance when they were using regular unleaded gasoline, oxygenated fuel, or a cross-fuelled mixture of both. Overall, it was found that the S1.0 fuel performed relatively well compared to gasoline once the vehicle

was warmed up, but had slightly poorer cold-engine driveability. Under no circumstance did the S1.0 methanol blend prevent vehicle operation.

5.1/ Road Testing Procedure

There were two types of road tests performed in the program. These were the Downsview or "home" road tests and the "away from home" road tests. The home driveability test route was based around the MTC Downsview complex, which was the home base for most of the S1.0 vehicles in the fleet. The route was designed by MTC to reflect a diverse driving schedule and consisted of both highway and city driving with varied gradability.

Since many of the vehicles were not available at Downsview, occasionally "away from home" driveability tests were performed. In these instances an alternate test route simulating the original route as closely as possible was used.

Appendix F details the Downsview driveability route and testing schedule as well as the procedure used for the "away from home" road tests.

For each test a driveability test sheet was used to record all data pertaining to the vehicles' performance, as well as any comments the driver considered important (Figure 10).

A driveability demerit point system was developed for this program to obtain a numerical indication of the performance of a vehicle for each road test. It was based on similar systems used by the CRC. Demerit points were assigned to a vehicle according to the type and severity of a driveability fault, the length of cranking time, and the amount of run-on time (Figure 11).

A rating of either "good," "acceptable," or "poor" was assigned to each driveability test, according to the number of demerit points accumulated on the test. A test with 20 or less demerit points rated "good," between 21 and 40 rated "acceptable," and over 40 rated "poor."

Driveability Test Report
Methanol Fuel Test Program

VEHICLE NUMBER: _____ TEST DATE: _____

TEST DRIVER: _____ START TIME: _____

WEATHER: OUTSIDE TEMPERATURE: ____ °C TEST DURATION: _____ min

HUMIDITY: ____ END ODOMETER: _____ km

FUEL IN TANK: S1.0 ___ OR GAS ___

ENGINE STARTING

	COLD	WARM
TOTAL CRANKING TIME (s)		
NUMBER OF ATTEMPTS		

IGNITION OFF

RUN-ON TIME: ____ s

OCCURRING PROBLEMS	SEVERITY Enter number of occurrences of each type		ENGINE TEMPERATURE		DRIVING MANOEUVRE WHICH MOST CAUSES THIS PROBLEM TO OCCUR
	Noticeable	Troublesome	Cold	Warm	
ROUGH IDLE					
BACKFIRE					
SURGE					
HESITATION					
STUMBLE					
STALLS					

SUMMARY & COMMENTS: Also note any extraordinary conditions.

OVERALL RATING

GOOD _____ ACCEPTABLE _____ POOR _____ DEMERIT POINTS: _____

Figure 10/ Driveability Test Sheet

Driveability Demerit Point System

ENGINE STARTING

DEMERIT POINTS

	COLD WARM		
TOTAL CRANKING TIME (s)	•	-3	= _____
NUMBER OF ATTEMPTS			

IGNITION OFF

RUN-ON TIME: _____ s (x3) - _____

MALFUNCTION WEIGHT	OCCURRING PROBLEMS	SEVERITY Enter number of occurrences of each type		ENGINE TEMPERATURE		
		Noticeable	Troublesome	Cold	Warm	
(1x)	ROUGH IDLE	(2x)	(3x)			- _____
(2x)	BACKFIRE	(2x)	(3x)			= _____
(2x)	SURGE	(2x)	(3x)			- _____
(3x)	HESITATION	(2x)	(3x)			= _____
(3x)	STUMBLE	(2x)	(3x)			- _____
	STALLS	IDLING (x8) • DRIVING (x24)				= _____

TOTAL DEMERITS = _____

Figure 11/ Driveability Demerit System

5.2/ Road Testing Results

The objective of the driveability tests, with respect to each vehicle in the fleet, was to complete a large number of driveability evaluations over a wide range of ambient conditions, with both S1.0 and gasoline used as fuels. This would provide a strong basis for comparison of the performance of the fuel blend relative to gasoline. This goal was met with a few vehicles; however, most of the vehicles were not available for testing on a regular basis at the Downsview complex due to their service schedules. Thus, there were some vehicles that were road tested extensively, whereas others were not tested at all.

A total of 302 driveability tests were completed over the test period. Of these, 172 were done while vehicles were using the S1.0 fuel blends, and 130 were done with gasoline as the fuel. A breakdown of the tests which rated "good," "acceptable," or "poor" for each vehicle is provided in Table 7.

The results of the driveability testing indicated that most vehicles experienced the same driving faults with both S1.0 and gasoline; however, those with S1.0 were more noticeable in some cases. The driveability of the vehicles above 5°C was essentially identical with S1.0 and gasoline; however, below this temperature the number of "poor" road tests with S1.0 began to increase at a more advanced rate than with gasoline.

The majority of demerit points were accumulated during the cold-start and drive portions of the driveability test. It was found that the S1.0 fuel exhibited slightly poorer driveability during the cold-start and drive testing, particularly in cold weather. The decrease in cold-engine driveability with some vehicles may be due to the leaning effect of the S1.0 fuel, particularly with vehicles having a lean calibration with gasoline.

The warm-engine driveability with S1.0 appeared to be just as good as with gasoline for all ambient conditions. The lack of driveability problems at high ambient temperatures indicates that seasonal fuel blending was adequate with the S1.0 fuel. This can be attributed to the adherence of the methanol blends to the unleaded gasoline fuel specifications.

Table 7/ Driveability Testing Results

Vehicle	S1.0 tests				Gasoline Tests			
	#	G	A	P	#	G	A	P
FLEET A								
77-413	4	1	2	1	2	2	0	0
78-209	1	0	0	1	0	0	0	0
78-1096	1	0	0	1	1	0	0	1
78-221	4	0	0	4	7	1	0	6
80-235	4	0	1	3	0	0	0	0
80-271	12	0	2	10	5	0	0	5
81-452	16	0	3	13	12	1	4	7
81-1771	5	1	2	2	0	0	0	0
82-101	0	0	0	0	0	0	0	0
FLEET B								
79-1224	9	2	6	1	3	1	2	0
79-1232	5	0	4	1	5	2	0	3
79-1601	12	4	6	2	6	1	4	1
79-1600	2	0	0	2	1	0	0	1
82-141	6	2	3	1	6	3	1	2
82-143	2	0	2	0	7	3	3	1
82-145	8	1	2	5	3	2	1	0
82-153	2	0	2	0	1	0	1	0
82-190	2	0	1	1	0	0	0	0
81-798	9	6	3	0	7	6	1	0
80-1256	0	0	0	0	0	0	0	0
80-1262	1	1	0	0	0	0	0	0
81-1790	0	0	0	0	1	0	0	1
80-1264	2	2	0	0	3	1	2	0
80-1263	3	3	0	0	5	3	1	1
79-1606	7	0	1	6	5	1	1	3
79-1630	0	0	0	0	0	0	0	0
81-1791	12	6	3	3	5	2	2	1
81-1789	3	2	1	0	7	6	1	0
80-1129	0	0	0	0	3	2	1	0
81-844	0	0	0	0	4	2	2	0
80-1154	19	5	7	7	18	2	14	2
80-1155	1	0	0	1	1	0	0	0
81-574	1	0	0	1	0	0	0	0
81-575	2	0	0	2	0	0	0	0
81-580	0	0	0	0	0	0	0	0
81-581	0	0	0	0	0	0	0	0
81-455	11	1	2	8	8	0	3	5
80-1172	6	1	1	4	3	3	0	0
80-1173	0	0	0	0	1	0	0	1
TOTAL	172	38	54	80	130	44	44	42

G=Good
A=Acceptable
P=Poor

#=Number of tests

Some of the vans in the fleet were found to experience a noticeable power loss with S1.0, compared to gasoline. The lower energy density of the S1.0 fuel (approximately 5%) translated into a loss of power with some vehicles.

Significant differences were found between the performance of the various makes and models of vehicles in the fleet. The Fairmonts, in particular, exhibited very poor cold-engine driveability with both S1.0 and gasoline, compared to the other vehicles. Driveability results for individual or groups of vehicles consisting of one model were tabulated according to the ambient temperature of the test and are found in Appendix G.

One fleet vehicle, a 1980 GMC van, was road tested extensively with both fuels. Of the 37 driveability evaluations performed on this vehicle, 19 were with S1.0 fuel blends and 18 with gasoline. This vehicle exhibited a severe hesitation regularly on the third wide-open-throttle (WOT) manoeuvre during cold drive, followed by minor hesitations and stumbles during the warm drive. In general, the same driveability problems occurred with both fuels but were more apparent with S1.0.

Another vehicle which had numerous tests completed on it was a 1981 Fairmont wagon. It had a total of 28 tests, 16 with S1.0 and 12 with gasoline. This vehicle, along with the other Fairmonts in the fleet, exhibited severe cold driveability problems with both fuels. Cold driveability appeared to be worse with S1.0; however, both fuels performed very poorly during the cold drive. Driving stalls on initial WOT and medium throttle (MT) manoeuvres were common, as well as frequent hesitations and stumbles. A lean A/F ratio calibration of these vehicles was likely responsible for the poor cold-engine performance. Warm-engine driveability with both fuels was very good for all ambient conditions.

The remaining vehicles in the fleet had too few driveability tests performed on them, and thus, it was not possible to draw any conclusions regarding comparative fuel performance on these vehicles. The results were therefore grouped into categories by model and year (Appendix G).

AMC

The 1979 Concords performed very well when using S1.0, with a lower "poor" rate than with gasoline. All vehicles experienced minor hesitations and/or stumbles on most cold WOT and some cold MT manoeuvres. Warm driveability was very good with both fuels. There were no noticeable differences between the performance of S1.0 and gasoline.

Chrysler

The Dodge vans had acceptable performance with S1.0 for all model years, experiencing some cold driveability faults and good warm driveability with S1.0 and gasoline. Two 1981 vehicles in particular were noted on various occasions to have smooth acceleration but not as much power with S1.0. The 1980 vehicles did not have enough tests on S1.0 to permit conclusions; however, all six tests performed with S1.0 at temperatures between 1 and 26°C rated "good."

General Motors

Of the two 1981 GMC vans in the fleet, only one was tested with S1.0 and gasoline; the other, with straight gasoline. The performance of the two vehicles with gasoline was very similar, producing good results with no "poor" ratings. The nine tests performed with S1.0 on one vehicle were also satisfactory, with six "good" and three "acceptable" ratings.

In summary, the fleet vehicles were found to operate satisfactorily with the S1.0 fuel. The driving faults experienced while using S1.0 were similar to those experienced with gasoline for all vehicles in the fleet. There were some indications of poorer cold-engine driveability (relative to gasoline) with S1.0 below 5°C; however, warm-engine driveability was the same with S1.0 and gasoline at all ambient conditions. There were cases reported of a decrease in power with some vans in the fleet when using S1.0.

5.3/ Vehicle User Survey and Complaint Records

The test participants agreed that it was imperative that they obtain opinions regarding the performance of the S1.0 fuel from MTC personnel who operated the fleet vehicles on a regular basis. Furthermore, records of all vehicle problems believed to be caused by the use of the fuel

blends were maintained.

During April 1983, a vehicle user survey was conducted. Nineteen operators assigned the regular use of an S1.0 vehicle were contacted. Information regarding the operation of 18 different vehicles under winter conditions was obtained. The survey consisted of five questions, four relating to the performance of the S1.0 fuel and one regarding the convenience of filling up with S1.0 at the Downsview complex (to ensure that all possible steps were taken to maximize S1.0 use). A section was available for general comments (Figure 12).

For the most part, operator reactions to the first three questions regarding the vehicle's performance with S1.0 tended to be "same" or "worse" (Table 8). The most common remark in question 4 was that the vehicle had less power when using the S1.0 fuel. The response to question 5 indicated that for the majority of drivers, filling up at Downsview was somewhat inconvenient because of their location of work. Some operators mentioned that their vehicles experienced some cold-weather driveability problems, such as surges, hesitations, stumbles, or rough idling, with the S1.0 fuel but not with gasoline. The responses tended to be more negative for the vans in the survey.

The results of this survey indicate that some of the regular MTC operators noticed a decrease in the performance of S1.0 compared to gasoline. The noticeable loss of power, as well as the slight increase in cold-engine driveability problems experienced with some vehicles in the fleet when using S1.0, were confirmed by the driveability test results. Dynamometer fuel consumption tests did not support any claim of increased fuel consumption when S1.0 was used.

To keep records of vehicle performance problems caused by the use of S1.0, vehicle complaint reports were maintained. Of the complaints filed, only two were found to be directly related to the methanol fuel blend, and these problems were resolved early in the test program.

Two vehicles, a Concord wagon and a Dodge van, experienced severe driveability problems, which were traced to phase separation of the fuel blend. The cause of the phase separation was found to be salt and water

S1.0 Vehicle User Survey

VEHICLE No.: _____

USER: _____ WINTER

LOCATION: _____ SUMMER

USE: _____

QUESTIONS:

1. What is your opinion of the vehicle's performance on S1.0 fuel compared to gasoline? — Better / Same / Worse

2. How does S1.0 fuel consumption compare with that of gasoline? — Better / Same / Worse

3. What is your opinion of the cold-starting behaviour of S1.0 fuel compared with that of gasoline? — Better / Same / Worse

4. Are there any other noticeable differences between S1.0 and gasoline?

   _____

   _____

5. Does filling up at Downsview inconvenience you? — Very much / Slightly / Not at all

COMMENTS: _____

_____

_____

Figure 12/ Vehicle User Survey Sheet

Table 8/ Vehicle User Survey Results

Question	Better	Same	Worse	Do Not Know
1	1 (5%)	10 (53%)	8 (42%)	
2	2 (11%)	8 (42%)	5 (26%)	4 (21%)
3	1 (5%)	11 (58%)	7 (37%)	
4	Very Much	Slightly	Not at All	
5	8 (42%)	6 (32%)	5 (26%)	

leakage into the vehicles' fuel tanks during winter weather.

In the Concord, a previously corroded gas tank filler area was believed to be the source of water contamination. A new filler neck was installed and the fuel tank cleaned, resulting in acceptable vehicle operation. The gas tank of the Dodge van was found to be severely corroded inside and was removed and cleaned. The carburetor, fuel lines, and fuel tank filler spout were also cleaned, and no further major problems were experienced.

In both of these cases, the vehicle faults were already existent before operation on S1.0. The use of the test fuel exacerbated the situations, but once corrected, both vehicles performed well on both gasoline and S1.0.

6/ CONCLUSIONS

The results of the fleet trial demonstrated that the methanol/gasoline fuel blend tested was acceptable under fleet operation conditions. After two years of testing a 10% alcohol blend, S1.0, with a 7:3 methanol to co-solvent ratio, the following conclusions have been reached:

- The driveability of the fleet vehicles was deemed acceptable. Some vehicles experienced more noticeable driveability faults, including power loss, with S1.0 during cold-engine operation. This is partly due to the leaning effect of the methanol in the fuel blend. In no case did the S1.0 fuel prevent a vehicle from carrying out its day-to-day functions.

- There was little difference in the volumetric fuel consumption of S1.0, compared to gasoline. Despite the lower energy content of S1.0, some vehicles actually experienced lower fuel consumption rates with S1.0.

- The energy consumption of most vehicles while using S1.0 was equal to or less than that experienced with gasoline.

- In general, exhaust emissions of the fleet vehicles tested with the S1.0 blends met current Canadian standards. A trend for lower carbon monoxide emissions with the S1.0 fuels because of their leaning effect was apparent. Hydrocarbon emissions also tended to be lower with the S1.0 blends, compared to gasoline. There was no consistent trend observed with nitrogen oxide emissions.

- There was no detectable increase in engine wear due to usage of the methanol fuel blend. Both the elemental and bulk lubricant analyses of periodic engine oil samples showed that most vehicles exhibited normal wear patterns. In all but one case, the vehicles showing accelerated wear were also experiencing abnormal wear with gasoline before the test fuel was introduced. There was no indication of seal, gasket, or other elastomer deterioration.

- Equivalence ratio measurements confirmed that the use of methanol blends shifts the gasoline engine to operate at leaner air/fuel ratios.

This, however, did not appreciably affect vehicle use; thus, it was concluded that normal vehicles can operate on this fuel blend.

- The S1.0 oxygenated fuel (containing 4.0 wt.% oxygen) was blended to meet the existing CGSB specification for unleaded gasoline. It performed adequately when placed into general use in fleet vehicles under the normal climatic conditions experienced in Ontario.

- No problems existed with the quality of the fuel blends used in the demonstration. All blends met seasonal specifications, and monthly fuel samples showed that no deterioration in fuel quality occurred. The blended product was in bulk storage for long periods of time (up to six months) with only one volume removal, and yet no stratification or phase separation occurred. Some change in water content was noted, but no detrimental effects were experienced.

- The absence of phase separation difficulties indicated that the combination of the isopropanol (as the co-solvent), and its percentage content in the fuel (3% by volume), provided a stable blend.

- The fuel blend did not cause any material degradation problems. All vehicle and pump dispensing components that came in contact with the fuel were compatible.

- There is no need to change normal gasoline fuel handling and storage infrastructures, provided that free water is first excluded. The transportation and dispensing of the fuel blend in equipment designed to handle gasoline did not present any problems.

- The S1.0 fuel has demonstrated the technical viability of methanol as an octane improver that can displace gasoline in automobiles and light trucks. When used in low-percentage blends with a co-solvent, as a component of a fully formulated fuel meeting gasoline specifications, methanol can effectively increase the octane quality of the fuel without causing any significant detrimental effects on vehicle performance. The commercial viability of such blends would have to be tested further in an actual distribution system with consumer vehicles.

7/ BIBLIOGRAPHY

1/ "Driveability Performance of 1975 Passenger Cars at Intermediate Ambient Temperatures," Coordinating Research Council (CRC) Report No. 486, U.S., 1976.

APPENDIX A/ S1.0 BLEND FUEL -- SPECIFICATION VS. ACTUAL

Table A.1/ S1.0 Blend Fuel -- Specification vs. Actual

Test	Spec.	S1.0 (82) Actual	S1.0W (82/83) Actual	S1.0 (83/84) Actual
Density, kg/m^3	709-771	729	736	737
Dist. 10% Evap., °C	35-57	NA	NA	NA
50% Evap., °C	77-118	NA	NA	NA
90% Evap., °C	188 Max.	NA	NA	NA
E.P., °C	224 Max.	212	208	210
Residue %	2 Max.	1	1	1
Reid Vapor Press., kPa	75 Max. Summer	67	-	-
	103 Max. Winter	-	88	83
Octane Research	92.0 Min.	93.6	97.1	96.1
Octane Motor	84.0 Min.	85.2	86.2	85.8
Road Index (R+M)/2	88.5 Min.	89.4	91.7	91.0
Induction Period, h	6 Min.	Pass	Pass	Pass
ASTM Gums	4 Max.	3	2	3-4
Copper Strip Corrosion	1 Max.	1	1	1
MMT, mg/L	18 Max.	15	13.5	14
Alcohols, vol. %	10 Max.	10	10	10
Mercaptans, ppm	20 Max.	N/T	3	NA
Total Sulphur, wt. %	0.10 Max.	N/T	0.017	NA
Phase Separation, °C	-	N/T	-32	-45

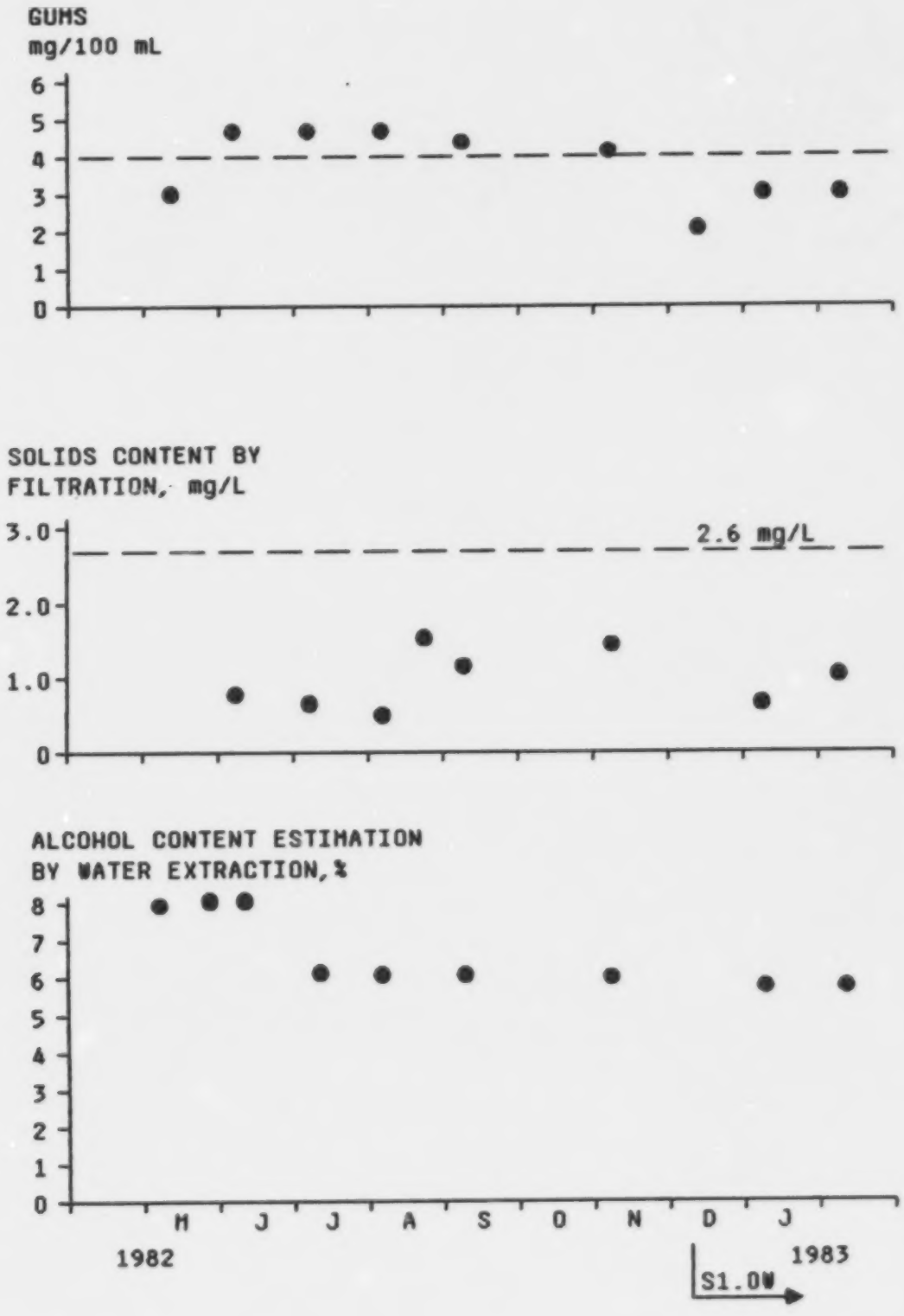

Figure A.1/ Alcohol, Solids, and Gum Content

APPENDIX B/ FUEL CONSUMPTION DATA OF FLEET A VEHICLES

Appendix B/ Fuel Consumption Data of Fleet A Vehicles
(Record Update from 820601 to 840430)

VEHICLE NUMBER	VOL. S1 (L)	VOL. GAS (OUT TOWN) (L)	VOL. GAS (IN TOWN) (L)	TOTAL VOL. GAS (L)	TOTAL VOL. FUEL (L)	% GAS (OUT TOWN)	% GAS (IN TOWN)	TOTAL % GAS USED	TOTAL % S1 USED	FUEL CONSUMPTION (L/100 KM)
77413000	3274.00	173.00	289.90	462.90	3736.90	4.63	7.76	12.39	87.61	22.75
78221001	3026.00	115.80	576.00	691.80	3717.80	3.11	15.49	18.61	81.39	12.49
81452001	1787.00	1153.80	596.10	1749.90	3536.90	32.62	16.85	49.48	50.52	10.42
78109607	3452.00	55.00	191.00	246.00	3698.00	1.49	5.16	6.65	93.35	30.49
81177102	3143.00	490.00	21.80	511.80	3654.80	13.41	0.60	14.00	86.00	14.70
78209000	4463.20	1467.40	331.60	1799.00	6262.20	23.43	5.30	28.73	71.27	12.93
80235000	2309.00	703.60	270.60	974.20	3283.20	21.43	8.24	29.67	70.33	10.98
80271000	1529.00	784.20	328.20	1112.40	2641.40	29.69	12.43	42.11	57.89	10.55
82101000	2025.00	903.50	137.00	1040.50	3065.50	29.47	4.47	33.94	66.06	11.16
	S1ALL= 25008.20 L			GASALL= 8588.49 L		FULALL= 33596.68 L		TOTAL S1 % =	74.44	
79122401	1334.00	562.90	0.0	562.90	1896.90	29.67	0.0	29.67	70.33	11.98
79123201	2982.10	807.80	769.20	1577.00	4559.10	17.72	16.87	34.59	65.41	11.75
79160101	1016.00	1940.80	1006.00	2946.80	3962.80	48.98	25.39	74.36	25.64	12.43
79160001	1004.00	621.80	49.00	670.80	1674.80	37.13	2.93	40.05	59.95	12.38
82141002	1111.10	4095.70	663.30	4758.99	5870.09	69.77	11.30	81.07	18.93	16.28
82143002	1339.00	3046.90	1808.40	4855.29	6194.29	49.19	29.19	78.38	21.62	16.95
82145002	1750.00	2053.50	1002.70	3056.20	4806.20	42.73	20.86	63.59	36.41	18.30
82153002	2650.00	920.30	237.70	1158.00	3808.00	24.17	6.24	30.41	69.59	17.14
82190002	2054.00	2213.00	1074.80	3287.80	5341.80	41.43	20.12	61.55	38.45	17.85
81798002	1926.00	2932.80	65.60	2998.40	4924.39	59.56	1.33	60.89	39.11	17.75

Appendix B/ (Cont'd)

VEHICLE NUMBER	VOL. S1 (L)	VOL. GAS (OUT TOWN) (L)	VOL. GAS (IN TOWN) (L)	TOTAL VOL. GAS (L)	TOTAL VOL. FUEL (L)	% GAS (OUT TOWN)	% GAS (IN TOWN)	TOTAL % GAS USED	TOTAL % S1 USED	FUEL CONSUMPTION (L/100 KM)
80125602	4316.00	2267.10	192.00	2459.10	6775.10	33.46	2.83	36.30	63.70	24.00
80126202	4442.00	1484.00	1082.60	2566.60	7008.60	21.17	15.45	36.62	63.38	19.72
81179002	949.00	7216.20	726.90	7943.10	8892.10	81.15	8.17	89.33	10.67	18.88
80126402	3149.00	3920.10	1310.00	5230.10	8379.10	46.78	15.63	62.42	37.58	22.77
80126302	581.00	5183.18	275.50	5458.68	6039.68	85.82	4.56	90.38	9.62	16.70
79160602	1780.00	1815.00	524.30	2339.30	4119.30	44.06	12.73	56.79	43.21	24.14
79163002	0.0	5432.97	1179.60	6612.57	6612.57	82.16	17.84	100.00	0.0	24.26
81179102	844.00	3348.60	505.80	3854.40	4698.39	71.27	10.77	82.04	17.96	16.40
81178902	1115.00	3125.00	1141.30	4266.29	5381.29	58.07	21.21	79.28	20.72	16.10
80112906	503.00	2126.50	1510.00	3636.50	4139.50	51.37	36.48	87.85	12.15	21.91
81844007	102.00	4990.09	2678.00	7668.09	7770.09	64.22	34.47	98.69	1.31	22.26
80115407	1588.00	179.60	70.00	249.60	1837.60	9.77	3.81	13.58	86.42	13.88
80115507	1177.10	6182.45	2851.60	9034.04	10211.14	60.55	27.93	88.47	11.53	27.07
81574000	805.10	1714.30	271.40	1985.70	2790.80	61.43	9.72	71.15	28.85	10.33
81575000	2678.00	677.70	540.50	1218.20	3896.20	17.39	13.87	31.27	68.73	12.81
81580000	1674.00	644.50	664.40	1308.90	2982.90	21.61	22.27	43.88	56.12	10.07
81581000	939.00	683.50	1186.00	1869.50	2808.50	24.34	42.23	66.57	33.43	9.91
81455001	1385.00	1076.00	461.42	1537.42	2922.42	36.82	15.79	52.61	47.39	11.91
80117201	1157.00	2271.80	550.20	2822.00	3979.00	57.09	13.83	70.92	29.08	10.54
80117301	562.00	2752.10	524.19	3276.29	3838.29	71.70	13.66	85.36	14.64	13.26

S10ALL= 46912.39 L GASALL=101208.06 L FULALL=148120.25 L TOTAL S10 % = 31.67

APPENDIX C/ ENERGY CONSUMPTION OF THE TEST FUEL -- SAMPLE CALCULATION

APPENDIX C/ ENERGY CONSUMPTION OF THE TEST FUEL -- SAMPLE CALCULATION

Test Fuel: S1.0W('83/'84)

Elemental Analysis (by weight):

Carbon	81.93 %
Hydrogen	13.69 %
Oxygen	4.38 %

Number of Atoms:

Carbon	81.93/12.011 =	6.82
Hydrogen	13.69/ 1.008 =	13.58
Oxygen	4.38/15.994 =	0.27

General Formula: CH_xO_y

$x = 13.58/6.82 = 1.99$

$y = 0.27/6.82 = 0.04$

Molecular Wt = 12.011 + (1.008)(1.99) + (15.994)(0.04) = 14.66 (g/g mol)

Basis is 1 kg fuel: 1000/14.66 = 68.22 g mol fuel

Assuming all hydrogen forms water,
moles water formed = (68.22)(1.99)/2 = 67.92 g mol

Heat of vaporization of water = 44 kJ/g mol (standard conditions)

Heat to vaporize water = (44)(67.92) = 2.99 MJ (per 1 kg fuel)

Upper heating value (UHV) measured as 44.47 MJ/kg fuel

Therefore, lower heating value (LHV):

LHV = UHV - heat required to vaporize water

= 44.47 - 2.99 = 41.48 MJ/kg

Then for a given vehicle,

Energy Consumption = Fuel Consumption (L/km) x Fuel Density (kg/L) x LHV (MJ/kg)

APPENDIX D/ FUEL CONSUMPTION AND EXHAUST EMISSIONS OF FLEET A

APPENDIX D/ ENERGY Consumption and Exhaust Emissions of Fleet A

		FUEL CONSUMPTION					EMISSIONS (g/mi)		
Vehicle	Fuel	Urban (MJ/km)	Highway (MJ/km)	Combined (MJ/km)	Combined (L/100 km)	STD Deviation of Combined Fuel Consumption	HC	CO	NO_x
Ford Maverick	SI (82)	5.19	3.73	4.53	14.43	0.07	1.46	23.61	4.12
6 Cyl.	SIW (82/83)	5.09	3.95	4.57	14.57	0.03	1.50	18.82	2.79
(4.1 L [250 CID])	Gas	5.00	3.83	4.48	14.24	0.06	1.63	25.96	5.08
77-413	S1 (83)	4.67	3.43	4.12	13.53	0.05	3.04	28.48	6.33
(A)	S1 (83/84)	4.85	3.59	4.28	13.90	0.03	2.28	20.00	5.45
Chev Impala	S1 (82)	4.94	3.44	4.27	13.59	0.01	2.10	19.05	2.95
V8	S1W (82/83)	5.07	3.54	4.38	13.95	0.16	1.90	11.83	2.87
(5.0 L [302 CID])	Gas	5.26	4.00	4.67	14.16	0.07	2.13	26.05	2.00
78-209	S1 (83)	5.87	4.04	5.05	16.60	0.12	1.14	11.93	2.10
(B)	S1 (83/84)	5.31	3.59	4.54	14.80	0.04	1.20	11.70	2.07
Dodge 300	S1 (82)	6.61	5.23	5.89	19.07	0.25	3.13	47.47	4.17
V8	S1W (82/83)	6.67	5.34	6.07	19.33	0.01	4.39	86.60	2.50
(5.0 L [302 CID])	Gas	7.27	5.90	6.65	20.15	0.13	4.86	116.95	1.85
78-1096	S1 (83)	7.71	5.69	6.75	22.20	0.03	4.42	102.78	2.38
(C)	S1 (83/84)	7.07	5.32	6.28	20.53	0.05	4.65	82.95	2.62
AMC Concord	S1 (82)	4.62	3.24	3.89	12.39	0.01	1.77	17.97	2.35
6 Cyl.	S1W (82/83)	4.62	3.26	4.01	12.76	0.08	2.06	11.62	2.09
(3.8 L [232 CID])	Gas	4.49	3.28	3.95	11.96	0.04	1.68	14.46	2.92
78-221	S1 (83)	4.67	3.26	4.03	13.26	0.01	1.76	13.94	2.18
(D)	S1 (83/84)	4.10	3.05	3.63	11.86	0.03	2.18	9.53	3.03
Ford Fairmont	S1 (82)	3.95	3.17	3.60	11.45	0.07	0.89	6.73	2.41
6 Cyl.	S1W (82/83)	3.89	3.15	3.56	11.33	0.02	0.90	7.44	2.49
(3.3 L [200 CID])	Gas	3.93	3.26	3.63	11.00	0.05	1.44	19.07	1.94
80-235	S1 (83)	3.92	3.19	3.56	11.66	0.05	1.36	12.38	1.78
(E)	S1 (83/84)	3.94	2.81	3.42	11.19	0.07	1.78	22.09	2.51

APPENDIX D/ (Cont'd)

		FUEL CONSUMPTION					EMISSIONS (g/mi)		
Vehicle	Fuel	Urban (MJ/km)	Highway (MJ/km)	Combined (MJ/km)	(L/100 km)	STD Deviation of Combined Fuel Consumption	HC	CO	NO_x
Ford Fairmont	SI (82)	3.77	3.05	3.45	10.98	0.02	0.62	2.47	2.40
6 Cyl.	SIW (82/83)	3.95	3.16	3.60	11.45	0.08	0.93	6.65	2.10
(3.3 L [200 CID])	Gas	4.13	3.24	3.73	11.30	0.03	1.34	14.52	2.30
80-271	S1 (83)	3.88	3.08	3.52	11.57	0.01	1.73	12.45	2.67
(F)	S1 (83/84)	3.76	2.91	3.38	11.04	0.04	1.37	8.03	2.08
Ford Wagon	S1 (82)	4.46	3.12	3.75	11.94	0.04	1.80	27.30	1.51
6 Cyl.	S1W (82/83)	4.24	3.27	3.80	12.10	0.19	0.95	16.28	1.65
(3.3 L [200 CID])	Gas	4.57	3.70	4.18	12.67	0.02	2.08	46.25	1.35
81-452	S1 (83)	4.29	3.33	3.86	12.68	0.02	0.92	12.66	1.35
(G)	S1 (83/84)	4.24	3.24	3.79	12.31	0.04	1.91	21.46	1.92
Dodge Ram	S1 (82)	6.67	4.03	5.48	17.46	0.55	2.70	46.26	2.83
V8	S1W (82/83)	6.62	4.00	5.44	17.32	0.09	2.70	46.26	2.83
(5.2 L [318 CID])	Gas	6.38	4.08	5.19	15.71	0.36	3.01	41.98	2.70
81-1771	S1 (83)	6.18	3.93	5.16	16.97	0.06	3.31	35.48	2.88
(H)	S1 (83/84)	5.98	3.79	4.99	16.29	0.08	3.39	27.45	3.33
Plymouth Reliant	S1 (82)	3.19	2.30	2.79	8.88	0.001	1.14	7.02	2.07
4 Cyl.	S1W (82/83)	3.16	2.30	2.76	8.83	0.002	1.18	6.56	1.90
(2.6 L [156 CID])	Gas	3.49	2.53	3.06	9.26	0.003	1.46	15.64	1.92
82-101	S1 (83)	3.23	2.27	2.80	9.19	0.000	1.30	5.00	1.71
(I)	S1 (83/84)	3.18	2.18	2.73	8.91	0.000	1.48	6.40	1.43

APPENDIX E/ ENGINE OIL ANALYSES RESULTS

APPENDIX E/ ENGINE OIL ANALYSIS RESULTS

At the beginning of the demonstration program, control oil samples were taken from the test vehicles to provide a basis for comparison with future samples taken during the S1.0 test period. The next three oil sample intervals were 3000 km apart, starting with the first oil sample or oil change (whichever was most recent). The following samples were taken at 5000 km intervals until the spring of 1983, when it was extended to 8000 km. A specially equipped vehicle that uses engine vacuum to draw engine oil through the test vehicles' dipstick tube was employed to obtain the 500 mL samples.

Table E.1/ Used Engine Oil Analysis -- Fleet A

Unit Identification	km	cSt @ 40°C	cSt @ 100°C	VI	TBN	Pentane Insoluble	Toluene Insoluble	Glycol
77-413-000-60	4 759	95.6	12.9	132	6.4	0.14	0.13	Neg.
	7 401	97.1	12.8	128	6.4	0.39	0.27	Neg.
78-209-000-11	6 890	104.2	13.5	129	5.9	0.10	0.09	Neg.
	10 147	94.1	12.7	130	6.5	0.26	0.21	Neg.
78-221-001	7 796	103.7	13.6	131	5.2	0.25	0.24	Neg.
	7 917	79.4	11.0	125	6.1	0.34	0.32	Neg.
78-1096-007-20	1 522	79.6	11.7	140	6.7	0.26	0.24	Neg.
	8 328	125.5	15.4	128	7.0	0.48	0.47	Neg.
80-235-000-25	3 370	74.5	11.1	140	7.0	0.07	0.05	Neg.
	8 223	94.9	13.6	135	5.8	0.15	0.13	Neg.
80-271-000-25	6 945	77.1	11.0	131	5.4	0.18	0.16	Neg.
	9 060	78.1	11.0	129	4.9	0.26	0.19	Neg.
	7 580	80.9	11.6	124	5.8	0.18	0.14	Neg.
81-452-001-25	5 187	80.6	11.7	139	6.2	0.17	0.15	Neg.
	9 105	76.7	11.8	148	5.9	0.19	0.17	Neg.
81-1771-002-20	7 108	93.1	12.8	135	4.3	0.37	0.13	Neg.
	7 608	94.8	12.7	130	6.3	0.15	0.13	Neg.
82-101-000-75	9 743	108.5	13.9	129	5.4	0.25	0.14	Neg.
	9 390	106.9	13.4	124	6.2	0.21	0.17	Neg.

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Table E.2/ Used Engine Oil Analysis -- Fleet B

Unit Identification	km	cSt @ 40°C	cSt @ 100°C	VI	TBN	Pentane Insoluble	Toluene Insoluble	Glycol
79-1232-001-24	9 757	111.4	14.2	129	5.6	0.18	0.12	Neg.
79-1600-001-24	1 248	92.5	12.9	138	7.4	0.09	0.03	Neg.
	7 596	87.1	12.0	131	6.5	0.10	0.09	Neg.
	12 003	81.7	11.7	135	5.2	0.11	0.07	Neg.
79-1601-001-24	2 245	98.3	12.7	125	7.2	0.12	0.08	Neg.
	11 064	108.4	13.3	120	5.2	0.24	0.14	Neg.
79-1606-002-11	2 761	74.4	11.0	138	7.3	0.25	0.05	Neg.
79-1630-002-11	7 834	50.5	10.5	205	7.5	0.32	0.11	Neg.
	7 542	74.2	11.7	151	5.4	0.18	0.12	Neg.
80-1129-006-20	3 036	69.3	10.8	145	5.2	0.48	0.42	Neg.
	9 096	104.6	13.8	133	6.2	0.57	0.51	Neg.
80-1154-007-11	6 284	94.8	13.1	136	5.7	0.39	0.30	Neg.
80-1172-001-25	10 981	114.6	14.3	127	5.1	0.13	0.09	Neg.
80-1173-001-25	9 693	63.9	10.4	151	5.3	0.18	0.09	Neg.
80-1256-002-20	8 452	97.1	13.2	134	7.0	0.17	0.04	Neg.
	6 737	71.4	11.1	146	6.7	0.41	0.31	Neg.

Table E.2/ (Cont'd)

Unit Identification	km	cSt @ 40°C	cSt @ 100°C	VI	TBN	Pentane Insoluble	Toluene Insoluble	Glycol
80-1262-002-20	8 575	94.2	13.0	136	5.3	0.45	0.41	Neg.
	9 527	94.8	13.4	142	6.1	0.34	0.27	Neg.
	6 782	80.7	11.9	142	5.8	0.30	0.24	Neg.
80-1263-002-20	3 014	54.3	9.5	159	5.4	0.62	0.43	Neg.
80-1264-002-20	3 335	47.3	8.4	156	5.3	0.64	0.58	Neg.
	11 485	60.4	9.6	142	5.5	0.92	0.77	Neg.
81-455-001-25	3 833	80.4	11.5	134	6.5	0.27	0.13	Neg.
	9 067	88.1	12.2	133	5.5	0.12	0.06	Neg.
81-574-000-25	7 585	80.2	11.6	136	6.1	0.13	0.13	Neg.
	10 632	64.7	10.2	144	4.6	0.18	0.13	Neg.
81-575-000-25	10 034	80.8	11.4	132	6.1	0.17	0.16	Neg.
81-580-000-24	11 373	62.0	10.0	141	5.0	0.39	0.14	Neg.
	7 742	60.7	10.3	157	3.8	0.13	0.07	Neg.
81-581-000-24	19 634	90.3	10.0	89	3.7	0.14	0.10	Neg.
	6 457	64.7	10.0	140	4.9	0.20	0.12	Neg.
81-798-002-11	4 413	92.9	13.5	146	6.1	1.04	0.62	Neg.
	13 127	75.9	11.7	149	5.1	0.61	0.54	Neg.
81-844-007-11	4 535	77.3	10.9	129	4.9	0.61	0.51	Neg.
	7 559	79.1	11.8	142	4.1	0.50	0.45	Neg.
81-1789-002-20	8 061	114.1	14.1	100	5.4	0.23	0.20	Neg.
81-1790-002-20	9 390	75.3	11.6	147	2.0	1.85	1.72	Neg.
	7 511	85.5	12.1	136	4.9	0.46	0.45	Neg.

Table E.2/ (Cont'd)

Unit Identification	km	cSt @ 40°C	cSt @ 100°C	VI	TBN	Pentane Insoluble	Toluene Insoluble	Glycol
81-1791-002-20	8 548	50.2	8.5	146	5.6	0.47	0.34	Neg.
	10 494	74.6	11.2	145	5.3	0.58	0.52	Neg.
82-141-002-20	5 815	104.7	11.9	99	6.2	0.26	0.15	Neg.
	2 677	96.6	11.5	107	5.5	0.33	0.31	Neg.
	8 053	87.4	12.2	134	6.2	0.10	0.05	Neg.
82-143-002-20	8 978	81.0	11.6	134	5.5	0.34	0.28	Neg.
82-145-002-20	3 743	82.5	11.6	132	7.0	0.25	0.15	Neg.
	6 221	101.5	13.4	131	7.0	0.14	0.06	Neg.
82-153-002-20	5 779	75.0	11.4	144	7.0	0.28	0.25	Neg.
	9 581	90.4	12.1	127	6.4	0.26	0.20	Neg.
82-190-002-20	5 310	80.7	11.5	134	6.7	0.20	0.16	Neg.
	9 443	103.0	13.0	122	5.9	0.20	0.17	Neg.

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Table E.3/ Elemental Analysis (ppm) -- Fleet A

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
77-413-000-60								
Control Sample	4 795	37	6	13	268	4	41	Abnormal
Second Sample	1 707	34	4	30	92	2	33	Abnormal
Third Sample	1 687	6	1	45	44	2	9	Abnormal
Fourth Sample	4 759	5	1	74	82	1	19	Abnormal
Fifth Sample	7 401	8	1	121	105	3	25	Abnormal
78-209-000-11								
Control	6 992	3	1	3	33	1	9	Normal
	3 785	10	5	51	113	5	24	Abnormal
	5 531	13	7	66	169	6	25	Abnormal
	4 626	8	5	46	62	3	35	Abnormal
	6 890	10	7	63	81	5	40	Abnormal
	4 045	13	5	49	54	4	23	Abnormal
	10 147	17	7	70	74	5	28	Abnormal
	9 676	2	1	30	31	1	11	Abnormal
78-221-001								
Control	1 133	4	1	1	35	1	9	Abnormal
	1 121	3	1	1	19	1	12	Abnormal
	2 925	5	2	4	28	1	12	Abnormal
	2 061	4	1	2	21	1	14	Abnormal
	7 796	1	1	3	17	1	12	Normal
	10 587	12	4	10	75	5	33	Normal
	7 917	3	2	29	44	2	12	Abnormal

Table E.3/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
78-1096-007-20								
Control	3773	4	4	1	107	2	11	Normal
Second	1066	7	4	3	89	2	13	Normal
Third	3248	21	12	12	202	9	51	Abnormal
Fourth	9	3	2	2	45	1	16	Normal
Fifth	1522	12	7	12	127	6	30	Normal
Sixth	8328	25	20	25	303	20	49	Abnormal
80-235-000-25								
Control	4964	3	1	1	54	2	8	Normal
	1965	4	1	2	27	2	14	Normal
	3462	3	2	2	33	2	11	Normal
	399	3	1	1	8	1	10	Normal
	3370	3	1	2	22	1	14	Normal
	8599	6	2	4	43	4	12	Normal
	8223	3	1	2	42	1	1	Normal
80-271-000-25								
Control	1605	3	1	1	28	1	7	Normal
	1980	5	1	6	32	2	13	Normal
	4215	7	2	7	43	2	12	Normal
	1927	2	1	2	18	1	7	Normal
	6945	8	2	5	61	3	16	Normal
	9060	7	2	5	73	3	16	Normal
	7580	3	1	25	51	1	11	Normal
81-452-001-25								
Control	2465	3	1	4	21	3	11	Normal
	3815	4	2	3	45	2	11	Normal
	3132	4	2	3	32	1	14	Normal
	5187	5	2	4	59	2	99	Normal
	9105	3	1	4	51	1	67	Normal

Table E.3/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
78-1771-002-20								
Control	1 092	4	3	7	82	5	13	Normal
Second	1 847	4	2	6	47	3	11	Normal
Third	5 960	8	5	13	91	4	12	Normal
Fourth	3 301	4	3	8	42	2	21	Normal
Fifth	7 108	15	8	15	93	9	40	Normal
Sixth	10 320	30	11	18	114	14	41	Normal
Seventh	7 608	2	1	9	28	1	17	Normal
82-101-000-75								
Control	120	4	1	5	20	3	13	Normal
	4 438	7	11	4	27	4	11	Normal
	4 928	7	11	4	27	4	11	Normal
	1 901	11	31	6	32	6	24	Abnormal
	4 010	6	18	4	16	5	12	Normal
	9 743	14	39	6	29	9	24	Normal
	9 390	6	22	4	23	2	20	Normal

Table E.4/ Elemental Analysis (ppm) -- Fleet B

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
79-1224-001-24								
First	4 382	4	1	1	28	1	6	Normal
Second	2 417	4	1	1	31	1	10	Normal
Third	2 804	6	2	1	36	3	11	Normal
79-1232-001-24								
First	6 104	3	2	1	43	1	7	Normal
	9 268	7	3	2	35	2	15	Normal
	4 416	5	2	1	34	1	14	Normal
	5 836	11	3	3	54	1	13	Normal
	2 017	4	1	1	20	2	11	Normal
	9 757	7	2	3	64	2	21	Normal
79-1600-001-24								
Control	1 869	4	1	4	34	1	11	Normal
	31	3	1	1	9	1	10	Normal
	1 855	4	1	7	29	2	12	Normal
	1 248	3	1	2	22	1	11	Normal
	2 849	7	1	9	44	3	17	Normal
	7 596	4	1	7	47	1	12	Normal
	12 003	5	1	9	50	2	17	Normal
79-1601-001-24								
Control	3 652	4	1	1	24	1	7	Normal
	163	3	1	1	11	1	9	Normal
	566	4	2	2	28	1	8	Normal
	2 245	9	3	2	48	2	17	Normal
	11 064	13	6	8	104	2	20	Normal

Table E.4/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
79-1606-002-11								
First	1610	6	1	1	28	1	10	Normal
Second	5222	10	1	3	35	1	11	Normal
Third	1057	6	1	2	23	1	14	Normal
Fourth	1930	7	2	2	30	1	15	Normal
Fifth	2761	12	2	4	40	2	23	Normal
79-1630-002-11								
First	3769	14	1	2	33	1	9	Normal
	2	4	1	1	11	1	10	Normal
	3018	13	2	3	42	1	14	Normal
	7834	22	13	3	96	4	25	Normal
	7542	15	2	2	100	1	15	Normal
80-1129-006-20								
First	2136	11	11	15	102	4	11	Normal
	1485	9	11	5	124	3	12	Abnormal
	3036	16	26	7	193	6	18	Abnormal
	9096	3	8	2	78	2	11	Normal
80-1154-007-11								
Control	1891	4	3	3	78	2	10	Normal
	5161	8	13	6	205	7	12	Abnormal
	5188	7	13	8	205	7	10	Abnormal
	6112	9	15	6	212	6	20	Abnormal
	6284	6	14	5	194	13	1	Abnormal

Table E.4/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
80-1155-007-11								
First	686	4	4	7	140	3	12	Abnormal
Second	5 573	20	15	13	237	13	12	Abnormal
Third	4 185	6	18	91	184	5	21	Abnormal
Fourth	357	8	3	9	66	3	62	Abnormal
80-1172-001-25								
Control	653	3	1	1	22	1	13	Normal
	1 972	4	1	1	33	1	11	Normal
	3 286	3	1	1	38	1	10	Normal
	5 192	2	1	2	35	1	13	Normal
	10 981	3	1	4	74	1	13	Normal
80-1173-001-25								
First	5 176	8	1	1	73	2	8	Normal
	9 693	9	1	2	74	2	15	Normal
80-1256-002-20								
First	1 270	7	4	6	130	2	11	Abnormal
	2 556	15	7	9	206	4	29	Abnormal
	2 700	5	6	5	57	30	22	Normal
	8 452	4	3	5	51	2	17	Normal
	6 737	4	5	4	84	2	16	Normal
80-1262-002-20								
First	5 848	8	18	6	135	4	12	Normal
	-	10	6	7	84	3	23	Normal
	8 575	15	17	9	155	5	30	Normal
	9 727	7	7	8	98	2	21	Normal

Table E.4/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
80-1263-002-20	1 907	9	9	4	80	3	11	Normal
First	3 215	3	3	6	40	1	8	Normal
	1 763	3	5	2	33	1	5	Normal
	3 014	3	9	12	55	1	30	Normal
	17 546	11	37	67	261	8	30	Abnormal
80-1264-002-20								
Control	5 098	10	33	5	489	7	24	Abnormal
	6 126	15	28	10	304	7	81	Abnormal
	6 165	12	34	7	216	6	28	Abnormal
	3 335	4	13	3	139	2	8	Abnormal
	11 353	28	41	9	616	16	33	Abnormal
	11 485	4	20	15	467	4	27	Abnormal
	6 782	4	4	6	57	1	17	Normal
81-455-001-25								
Control	2 832	5	4	3	103	3	10	Normal
	2 534	3	1	1	24	1	11	Normal
	6 036	8	1	5	35	4	19	Normal
	983	3	1	1	12	1	12	Normal
	3 833	3	1	2	29	1	14	Normal
	9 067	1	1	2	31	1	8	Normal
81-574-000-25								
Control	8 333	11	2	2	115	3	10	Normal
	222	5	1	2	51	2	13	Normal
	4 104	9	2	3	83	2	38	Normal
	2 423	5	1	2	37	1	19	Normal
	7 585	8	1	3	84	2	24	Normal
	10 632	6	1	44	70	2	15	Normal

Table E.4/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
81-575-000-25								
First	3 530	4	1	2	28	1	8	Normal
	1 088	3	1	1	21	1	12	Normal
	1 937	4	1	1	29	2	24	Normal
	6 180	5	2	2	62	1	9	Normal
	2 037	4	2	2	28	3	11	Normal
	6 989	16	5	51	89	5	13	Normal
	10 034	3	2	5	64	1	18	Normal
81-580-000-24								
First	3 290	3	1	1	48	1	5	Normal
	6 342	14	1	3	77	4	11	Normal
	1 138	4	1	1	30	1	9	Normal
	2 319	4	1	2	37	1	8	Normal
	-	13	3	3	93	4	10	Normal
	5 524	6	1	2	49	4	14	Normal
	11 373	9	2	4	72	4	10	Normal
	7 742	6	1	3	50	1	14	Normal
81-581-000-24								
First	6 685	7	1	4	74	3	12	Normal
	10 071	12	4	3	82	7	11	Normal
	19 634	20	5	4	231	6	22	Normal
	6 457	6	3	4	134	3	18	Normal
81-798-002-11								
Control	1 068	10	27	3	183	7	13	Abnormal
	2 429	25	44	6	289	18	22	Abnormal
	4 743	6	28	3	143	7	16	Abnormal
	3 504	8	3	6	36	3	12	Normal
	-	6	2	6	32	3	13	Normal
	4 413	6	2	6	32	3	13	Normal
	13 127	19	47	4	225	16	23	Abnormal

Table E.4/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
81-844-007-11								
First	3 292	4	2	2	99	3	10	Normal
	1 081	3	1	1	54	3	12	Normal
	4 534	10	7	3	97	5	17	Normal
	4 534	1	1	1	39	1	6	Normal
	11 728	10	9	3	113	7	10	Normal
	7 559	8	16	1	183	3	14	Normal
81-1789-002-20								
First	2 846	4	1	9	55	3	7	Normal
	3 844	4	2	6	34	2	10	Normal
	8 061	3	3	5	46	2	12	Normal
81-1790-002-20								
First	3 750	8	3	15	73	7	13	Normal
	9 036	21	9	13	81	10	9	Normal
	7 845	22	18	9	203	12	14	Abnormal
	9 390	18	10	18	375	3	13	Abnormal
	7 511	4	4	7	82	2	10	Normal
81-1791-002-20								
Control	4 650	4	3	11	102	3	13	Normal
	1 965	4	2	9	49	2	15	Normal
	3 217	4	4	12	66	2	10	Normal
	8 548	3	5	10	52	4	21	Normal
82-141-002-20								
Control	88	5	1	30	38	7	13	New
	4 323	23	3	76	122	32	19	New
	5 815	4	3	8	39	8	9	Normal
	2 677	6	7	9	61	19	16	Normal
	8 053	2	1	2	26	1	7	Normal

Table E.4/ (Cont'd)

Unit Identification	km	Aluminum	Chromium	Copper	Iron	Tin	Silicon	Wear
82-143-002-20								
Control	62	9	1	20	35	10	10	New
	2467	6	2	20	32	6	11	New
	2735	4	1	7	21	2	18	New
	3454	4	2	10	32	5	13	New
	5117	4	3	9	39	10	13	Normal
	8978	2	4	4	34	3	9	Normal
82-145-002-20								
Control	17	12	1	28	50	11	13	New
	1083	20	2	76	86	28	14	New
	2915	13	2	66	78	23	18	New
	1943	3	2	26	31	6	14	New
	3743	5	4	31	48	16	24	Normal
	6221	4	4	26	40	10	22	Normal
82-153-002-20								
First	68	15	1	40	41	13	10	New
	6443	25	5	80	116	43	20	New
	2885	2	1	10	34	4	7	New
	5629	3	2	15	40	6	11	New
	5779	3	3	14	42	8	14	Normal
	9581	3	4	15	47	9	17	Normal
82-190-002-20								
Control	59	9	1	24	43	12	10	New
	4441	16	1	61	90	26	24	New
	2789	2	1	5	24	2	9	New
	5310	3	2	8	34	4	16	Normal
	7627	6	5	13	45	13	13	Normal
	9443	4	4	14	44	23	9	Normal

84-01-10

Table E.5/ Analysis of Unused Engine Oil

Property	Method	Result
Viscosity Grade	SAE	15W40
Viscosity, cSt @ 40°C	D-445	108.2
Viscosity, cSt @ 100°C	D-445	14.8
Viscosity Index	D-2270	141
Flash Point, °C	D-97	223
Pour Point, °C	D-92	-32
Total Acid No.	D-974	2.9
Total Base No.	D-974	6.9
Sulphated Ash, % wt.	D-874	0.9
Zinc, % wt.	SUN	0.15
Calcium, % wt.	SUN	0.17
Magnesium, % wt.	SUN	0.05
Sulphur, % wt.	SUN	0.87

APPENDIX F/ ROAD TESTING PROCEDURES

APPENDIX F/ ROAD TESTING PROCEDURES

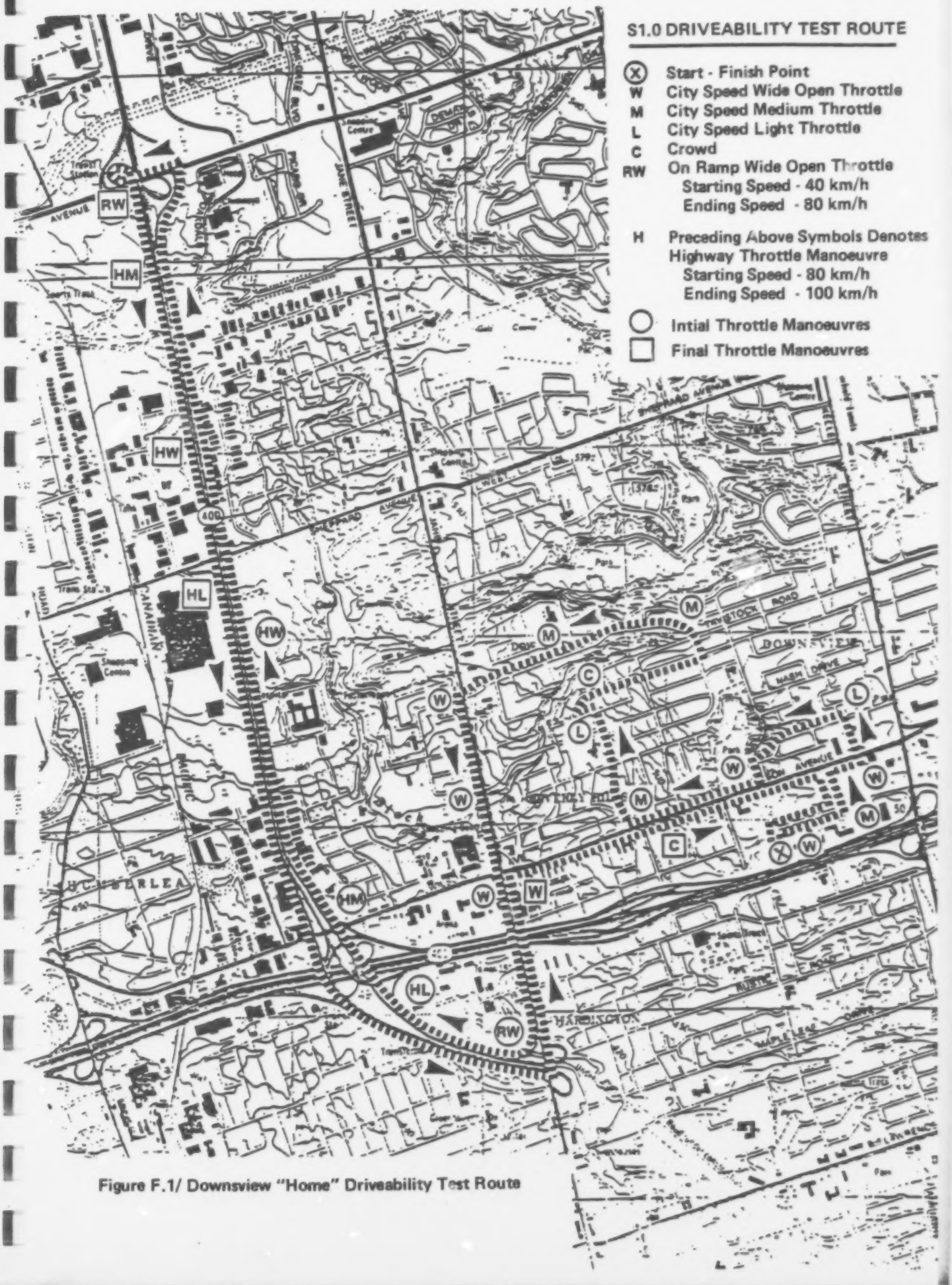
The road testing process consisted of four distinct phases: cold start, cold drive, warm drive, and warm start. A vehicle was qualified for a cold start only if before being started it had been cold soaked outdoors for a minimum of 8 h. The cold start was evaluated by total cranking time and idling quality.

The cold drive was judged from the point when the vehicle was placed in gear and began to move to the point of engine temperature equilibrium. Cold drive was evaluated by a series of heavy, medium, and light throttle applications from rest.

The warm drive period began after the engine had reached temperature equilibrium. Warm drive was evaluated by heavy, medium, and light throttle accelerations from rest as well as from 80 to 100 km/h on the highway, driving the vehicle at various steady-state speeds, and crowd accelerations (maximum throttle acceleration without transmission downshift).

The warm start occurred after the fully warmed-up engine had been soaked at ambient temperature for 5 min after being shut off. It was evaluated by total cranking time and idling quality.

The following pages include a map of the Downsview ("home") driveability test route (Figure F.1), the "home" and "away from home" road testing procedures, and descriptions of the throttle manoeuvres and driveability faults.


S1.0 DRIVEABILITY TEST ROUTE
(X) Start - Finish Point
W City Speed Wide Open Throttle
M City Speed Medium Throttle
L City Speed Light Throttle
C Crowd
RW On Ramp Wide Open Throttle
Starting Speed - 40 km/h
Ending Speed - 80 km/h
H Preceding Above Symbols Denotes
Highway Throttle Manoeuvre
Starting Speed - 80 km/h
Ending Speed - 100 km/h
Intial Throttle Manoeuvres
Final Throttle Manoeuvres
RW
HM
HW
HL
HW
HW
HM
HL
RW
W
M
C
L
X
W
M
C
L
W
M
W
W
W

F.1/ MTC Downsview Driveability Road Test -- Methanol Fuel Test Program

F.1.1/ Preliminary Notes

- Engine must be cold at start, preferably not yet driven this day.
- Test should be performed between 9:00 a.m. and 2:00 p.m.
- Complete, or have a co-driver complete, a copy of the "Driveability Test Report" during the test.
- The particular test outlined here is designed to start and finish at the District 42 compound. However, any point(s) in the MTC complex may be used, provided similar start, low speed, and finish cycles are used.

Test Length: 22.9 km 30 min

F.1.2/ Procedure

	Cycle	km	Procedure
1/	START	0.0	• Before start, pump gas twice to floor. • Crank engine with foot off gas. • Idle in neutral no longer than 30 s after a successful start. • Kick down to low idle, if possible. • In gear idle ~5 s. If vehicle stalls three times in a row during this idle do not kick down to low idle after next start.
2/	LOW SPEED	0.0	• Drive through parking lot manoeuvres with little or no throttle application.
		0.1	• Stop at compound gate. • Neutral idle ~5 s. • Throttle taps. • In gear idle ~5 s.

Note: After any stalls up to this point repeat the entire START CYCLE.

3/ CITY: In the city cycles, wide open throttle (WOT) accelerations are to be done only on arterial roads (e.g., Jane Street and Wilson Avenue). Accelerations on residential streets shall take place at light (LT) or medium (MT) throttle or constantly increasing throttle opening (crowd).

Legend: R = right turn
L = left turn
N, S, E, W = Compass heading after turn
e.g., "R - E Wilson" means turn right to head east on Wilson Avenue.

Cycle	km	Directions (from Gate)	Procedure
		R - E Downsview Avenue	WOT up hill
		L - N MTC road to Wilson	MT
	0.7	R - E Wilson	WOT
	0.8	L - N Agate	LT
	0.9	L - W Victory S - Julian	Coast
	1.7	R - W Wilson	WOT
	2.5	R - N Tumpane	MT
	3.1	L - W Forthbridge	LT
	3.2	R - N/E Calvington	Crowd up hill, without down-shifting.
	4.0	L - N/W Exbury	MT from stop signs.
	5.4	L - S Jane	Between this point and the Hwy 400 exit try to perform 3 WOT accelerations from a stop.
4/ HIGHWAY	7.2	R - N 400	WOT from low speed on each on ramp. Perform one more WOT at highway speeds going each way (i.e., to simulate highway passing. Also, do
	12.9	Around Finch Cloverleaf	
	17.3	S 400 onto Black Creek	

			one series of LT and MT 80-100 km/h accelerations and steady-speed cruises in each direction.
5/ CITY	19.3	L - N Jane	
	20.4	R - E Wilson	WOT, then coast. On long uphill, crowd throttle slowly.
	22.2	R - S MTC Road	
	22.4	R - W Downsview Avenue	
	22.9	Park in compound	
6/ FINISH		In gear idle 5 s.	
		Neutral idle 5 s.	
		Ignition off for 5 min.	
		Start again without touching gas pedal.	
		Ignition off after 5 s idle.	

F.2/ "Away from Home" Driveability Guidelines

1/ Usual cold-start procedure:

a) Pump gas twice.
b) Crank engine (no throttle).
c) 30 s neutral idle.
d) Kick down to low idle (if possible).
e) 5 s in gear idle.
f) Little or no throttle driving for short while, followed by 5 s neutral idle and 5 s gear idle.

2/ When engine is still cold do the following:

3 WOT
2 MT
2 LT
Crowd

all to be spaced over the first 6-10 km

3/ When warm:

3 WOT, city speed

highway manoeuvres:
- 2 low speed WOT to highway speed (if possible)
- 2 80-100 km/h WOT
- 2 80-100 km/h MT
- 2 80-100 km/h LT

1 WOT on city-type road

1 coast

4/ Perform usual shutdown and warm-start procedure:

a) in gear idle (5 s)

b) neutral idle (5 s)

c) ignition off for 5 min, restart without throttle application

F.3/ Definitions

Throttle Manoeuvre	Description of Manoeuvre
Wide Open Throttle (WOT) or Heavy Throttle (HT)	The throttle is depressed fully. Used for full power accelerations.
Medium Throttle (MT)	The throttle is depressed halfway. Used for medium power accelerations.
Light Throttle (LT)	The throttle is depressed slightly. Used for low power accelerations.
Crowd	The throttle opening is continuously increased with increasing speed. Used on high-grade hill climbing.
Coast	Throttle opening is closed as vehicle travels via its momentum.

F.4/ Description of Driveability Faults

Driveability Fault	Description of Fault
Rough Idle	Engine operation is not smooth. Vibration is noticeable or a troublesome pulsating idle exists.
Backfire	Combustion of the unburned air-fuel mixture, which takes place in the exhaust system rather than the combustion chamber.
Surge	Engine speed increases and decreases even though the driver has not changed the throttle position.
Hesitation	A temporary lack of initial response to a change in throttle position.
Stumble	A short, sharp reduction in acceleration rate experienced under acceleration or road load conditions.
Stall	Any occasion during a test that the engine stops with the ignition on.

APPENDIX G/ ROAD TESTING RESULTS

APPENDIX G/ ROAD TESTING RESULTS BY TEMPERATURE

Table G.1/ 1980 GMC Van (1154)

°C	# S1.0 Tests	S1.0 Results			# Gas Tests	Gas Results		
		Good	Acc.	Poor		Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	1	1	0	0	0	0	0	0
21 to 25	0	0	0	0	0	0	0	0
16 to 20	1	1	0	0	0	0	0	0
11 to 15	1	0	0	1	3	0	2	1
6 to 10	2	2	0	0	7	1	6	0
1 to 5	7	0	3	4	5	0	4	1
-4 to 0	5	1	4	0	1	0	1	0
-9 to -5	1	0	0	1	1	1	0	0
-14 to -10	1		0	1	0	0	0	0
-19 to -15	0	0	0	0	1	0	1	0
< -20	0	0	0	0	0	0	0	0
TOTALS	19	5	7	7	18	2	14	2

COMMENTS:

- This vehicle was road tested extensively.
- The vehicle exhibited a severe hesitation on the third WOT manoeuvre regularly with both S1.0 and gasoline.
- This was followed by minor hesitations and stumbles during warm drive (both fuels also).
- In general, the same driveability problems occurred with both fuels; however, the problems with S1.0 tended to be enhanced slightly. One driver noted that the vehicle had less power with S1.0.

Table G.2/ 1981 Fairmont Wagon (452)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	0	0	0	0	1	1	0	0
21 to 25	0	0	0	0	0	0	0	0
16 to 20	0	0	0	0	0	0	0	0
11 to 15	3	0	2	1	0	0	0	0
6 to 10	3	0	0	3	2	0	1	1
1 to 5	7	0	1	6	4	0	2	2
-4 to 0	2	0	0	2	4	0	1	3
-9 to -5	1	0	0	1	1	0	0	1
-14 to -10	0	0	0	0	0	0	0	0
-19 to -15	0	0	0	0	0	0	0	0
< -20	0	0	0	0	0	0	0	0
TOTALS	16	0	3	13	12	1	4	7

COMMENTS:

- This vehicle was road tested extensively.
- Cold driveability with both fuels produced severe problems. Driving stalls on initial WOT and MT manoeuvres were common, as well as frequent troublesome hesitations and stumbles. Throttle manipulation was often required to prevent stalls. The cold driveability was aggravated by a malfunctioning choke which would disengage prematurely.
- Warm engine driveability with both fuels was essentially flawless at all ambient conditions, with no driveability problems noted.
- No clear difference between the performance of S1.0 and gasoline was apparent. Both fuels exhibited similar poor cold driveability and excellent warm driveability.

Table G.3/ 1981 GMC Vans (798, 844)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
26 to 30	0	0	0	0	0	0	0	0
21 to 25	0	0	0	0	1	1	0	0
16 to 20	2	1	1	0	1	0	1	0
11 to 15	0	0	0	0	0	0	0	0
6 to 10	0	0	0	0	3	3	0	0
1 to 5	3	1	2	0	3	3	0	0
-4 to 0	2	2	0	0	2	1	1	0
-9 to -5	2	2	0	0	1	0	1	0
-14 to -10	0	0	0	0	0	0	0	0
-19 to -15	0	0	0	0	0	0	0	0
< -20	0	0	0	0	0	0	0	0
TOTALS	9	6	3	0	11	8	3	0

COMMENTS:

- Vehicle 81-798, a Suburban, had excellent performance with S1.0. Minor hesitations and stumbles were encountered during cold drive with each fuel. No significant difference between S1.0 and gasoline could be noticed during warm or cold drive.
- The regular MTC operator of 81-844 mentioned that the vehicle had less power with S1.0 when heavily loaded.

Table G.4/ 1980 Dodge Vans (1129, 1262, 1263, 1264)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	1	1	0	0	0	0	0	0
21 to 25	0	0	0	0	0	0	0	0
16 to 20	0	0	0	0	1	1	0	0
11 to 15	2	2	0	0	2	2	0	0
6 to 10	1	1	0	0	3	0	3	0
1 to 5	2	2	0	0	3	2	0	1
-4 to 0	0	0	0	0	2	1	1	0
-9 to -5	0	0	0	0	0	0	0	0
14 to -10	0	0	0	0	0	0	0	0
19 to -15	0	0	0	0	0	0	0	0
< -20	0	0	0	0	0	0	0	0
TOTALS	6	6	0	0	11	6	4	1

COMMENTS:

- Excellent performance was noted with both fuels for all vehicles.
- Cold operating problems occurred with gasoline at temperatures below 10°C, but not enough tests were conducted with S1.0 to permit comparison.

Table G.5/ 1981 Dodge Vans (1771, 1789, 1790, 1791)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	1	1	0	0	0	0	0	0
26 to 30	2	1	1	0	0	0	0	0
21 to 25	1	1	0	0	0	0	0	0
16 to 20	2	1	1	0	1	1	0	0
11 to 15	1	1	0	0	0	0	0	0
6 to 10	4	2	0	2	4	2	2	0
1 to 5	2	0	1	1	0	0	0	0
-4 to 0	3	1	1	1	3	2	0	1
-9 to -5	3	1	1	1	0	0	0	0
-14 to -10	0	0	0	0	3	1	1	1
-19 to -15	0	0	0	0	2	2	0	0
< -20	1	0	1	0	0	0	0	0
TOTALS	20	9	6	5	13	8	3	2

COMMENTS:

- In general, all vehicles performed well with both fuels, with minor cold driveability problems (hesitations and surges) and good warm driveability.
- Two vehicles, 1771 and 1791, were noted to have smooth acceleration with S1.0 but not enough power.
- No other significant problems were noted.

Table G.6/ 1982 Dodge Vans (141, 143, 145, 153, 190)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	1	0	1	0	0	0	0	0
26 to 30	0	0	0	0	0	0	0	0
21 to 25	2	1	1	0	1	1	0	0
16 to 20	1	1	0	0	0	0	0	0
11 to 15	2	0	1	1	1	0	1	0
6 to 10	3	1	2	0	3	2	1	0
1 to 5	9	0	5	4	3	1	2	0
-4 to 0	2	0	0	2	5	3	1	1
-9 to -5	0	0	0	0	0	0	0	0
-14 to -10	0	0	0	0	4	1	1	2
-19 to -15	0	0	0	0	0	0	0	0
< -20	0	0	0	0	0	0	0	0
TOTALS	20	3	10	7	17	8	6	3

COMMENTS:

- All vehicles performed well with both fuels. Performance was excellent above 10°C, but some cold driveability problems were encountered below 10°C. These included minor hesitations, surges, and stumbles, as well as idling stalls.
- Vehicle 145 experienced some problems while using S1.0 early in the test program (five poor road tests). Poor cold driveability and some warm driveability problems were experienced. The gasoline tests done on this vehicle near the end of the program were very good in comparison, probably because the vehicle had been tuned up by that time.
- There were no significant differences between S1.0 and gasoline.

Table G.7/ 1979 Concords (1224, 1232, 1600, 1601)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	0	0	0	0	1	1	0	0
21 to 25	1	0	1	0	1	1	0	0
16 to 20	3	2	1	0	0	0	0	0
11 to 15	3	1	1	1	2	1	1	0
6 to 10	5	2	2	1	6	1	4	1
1 to 5	7	1	5	1	1	0	0	1
-4 to 0	5	0	3	2	3	0	1	2
-9 to -5	4	0	3	1	0	0	0	0
-14 to -10	0	0	0	0	1	0	0	1
-19 to -15	0	0	0	0	0	0	0	0
< -20	0	0	0	0	0	0	0	0
TOTALS	28	6	16	6	15	4	6	5

COMMENTS:

- All vehicles experienced minor hesitations and/or stumbles on most cold WOTs and some cold MTs. Occasionally a troublesome fault would arise on a cold WOT. The same faults were experienced with both fuels.
- Warm driveability was faultless with both fuels.
- There were no noticeable differences between S1.0 and gasoline.

Table G.8/ 1981 Fairmonts (452, 455, 574, 575)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	0	0	0	0	1	1	0	0
21 to 25	0	0	0	0	0	0	0	0
16 to 20	1	0	1	0	1	0	1	0
11 to 15	6	1	2	3	0	0	0	0
6 to 10	5	0	1	4	2	0	1	1
1 to 5	11	0	1	10	8	0	4	4
-4 to 0	5	0	0	5	5	0	1	4
-9 to -5	2	0	0	2	2	0	0	2
-14 to -10	0	0	0	0	0	0	0	0
-19 to -15	0	0	0	0	1	0	0	1
< -20	0	0	0	0	0	0	0	0
TOTALS	30	1	5	24	20	1	7	12

COMMENTS:

- All vehicles exhibited severe cold driveability problems, with S1.0 and gasoline.
- All vehicles exhibited excellent warm driveability with both fuels.
- There was a slight indication of better cold driveability with gasoline; however, the same problems occurred with gasoline.

Table G.9/ 1980 Fairmonts (235, 271, 1172, 1173)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	0	0	0	0	0	0	0	0
21 to 25	2	0	1	1	0	0	0	0
16 to 20	1	0	1	0	1	1	0	0
11 to 15	3	0	0	3	1	0	0	1
6 to 10	4	0	0	4	2	1	0	1
1 to 5	6	1	1	4	1	0	0	1
-4 to 0	2	0	1	1	4	1	0	3
-9 to -5	2	0	0	2	0	0	0	0
-14 to -10	1	0	0	1	0	0	0	0
-19 to -15	0	0	0	0	0	0	0	0
< -20	1	0	0	1	0	0	0	0
TOTALS	22	1	4	17	9	3	0	6

COMMENTS:

- As with the 1981 Fairmonts, very poor cold driveability and excellent warm driveability were exhibited.
- There were not enough gasoline tests to get an indication of gas trends. There appears to be no difference from 1981 Fairmonts (i.e., same as S1.0).

Table G.10/ 1980 and 1981 Fairmonts
(452, 455, 574, 575, 235, 271, 1172, 1173)

°C	# S1.0 Tests	S1.0 Results Good	Acc.	Poor	# Gas Tests	Gas Results Good	Acc.	Poor
> 30	0	0	0	0	0	0	0	0
26 to 30	0	0	0	0	1	1	0	0
21 to 25	2	0	1	1	0	0	0	0
16 to 20	2	0	2	0	2	1	1	0
11 to 15	9	1	2	6	0	0	0	0
6 to 10	9	0	1	8	4	1	1	2
1 to 5	17	1	2	14	9	0	4	5
-4 to 0	7	0	1	6	9	1	1	7
-9 to -5	4	0	0	4	2	0	0	2
-14 to -10	1	0	0	1	0	0	0	0
-19 to -15	0	0	0	0	1	0	0	1
< -20	1	0	0	1	0	0	0	0
TOTALS	52	2	9	41	28	4	7	17

COMMENTS:

- Results are similar to 1981 and 1980 Fairmonts.
- There was no clear difference between S1.0 and gasoline.